PRELIMINARY DRAFT

San Francisco Groundwater Master Plan

Prepared by
San Francisco Water Department

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Acronyms and Abbreviations

AB	Assembly Bill
ac-ft	acre-feet
AWSS	Auxiliary Water Supply System
BART	Bay Area Rapid Transit
BAWUA	Bay Area Water Users Association
Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
DPW	Department of Public Works
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EOP	Emergency Operations Plan
FY	fiscal year
GIS	Geographical Information System
gpm	gallons per minute
MCL	maximum contaminant level
mgd	million gallons per day
mg/L	milligrams per liter
MOU	Memorandum of Understanding
NGVD	national Geodetic Vertical Datum of 1929
O&M	operation and maintenance
USGS	U.S. Geological Survey
WHP	wellhead protection
WWTP	wastewater treatment plant
yr	year

Glossary

AB3030 - The Groundwater Management Act (1992, California Water Code 10750 et seq) facilitates and encourages local public water agencies in developing and implementing groundwater management plans. The legislation identifies 12 elements that may be included in a groundwater management plan. These elements address evaluation or operation of a groundwater basin so that groundwater can be managed to maximize the total water supply while protecting groundwater quality.

Acre-foot (ac-ft) - A quantity or volume of water covering 1 acre to a depth of 1 foot; equal to 43,560 cubic feet or 325,851 gallons.

Aquifer - Saturated rock or sediment that is permeable enough to transmit significant quantities of water to wells and/or springs.

Aquifer Properties - Physical characteristics of an aquifer that influence the movement of groundwater through the aquifer. Aquifer properties include such characteristics as hydraulic conductivity and porosity.

Auxiliary Water Supply System (AWSS) - A separate high-pressure distribution system in the City of San Francisco that provides nonpotable water for firefighting.

Confining Low-Permeability Layer - A layer or zone of generally low permeability sediments, such as clay, that underlie or overlie more permeable aquifer material, such as sand and gravel. A low-permeability layer retards the vertical movement of groundwater.

Conjunctive Use - The coordinated management of groundwater and surface water supplies to increase the availability of water during periods of need. In conjunctive use operations, surface water may be obtained from surplus river flows, imported supplies, recycled water, and desalinated water. Recharge of a groundwater basin may be by "in lieu" means, whereby surplus surface water is used in place of groundwater, or by direct recharge of the water through spreading basins or injection wells.

Dewatering - The process of actively pumping or removing groundwater from a localized area during construction or for maintaining dry conditions under a completed structure in areas where groundwater levels are high.

Discharge - The volume of water flowing in a stream or through an aquifer past a specific point during a given period of time.

Drought Period - A hydrologic period consisting of 1 or more years during which runoff (or precipitation) is classified by the California Department of Water Resources as "below normal," "dry," or "critical."

Environmental Impact Report (EIR) - A detailed evaluation of the potential environmental effects of a proposed project.

Goal (as applied to the Groundwater Master Plan) - The Water Department's ultimate purpose in managing, developing, and using the City's groundwater.

Geographic Information System (GIS) - A computer-based information system used to maintain and relate information.

Groundwater - Water that occurs beneath the land surface and fills the pore spaces of the sediment or rock formation in which it is situated.

Groundwater Basin - A continuous body of unconsolidated sediments that contain groundwater and the surrounding surface drainage area.

Groundwater, Confined - Water within an aquifer that is under greater than atmospheric pressure due to an overlying layer that has a low permeability.

Groundwater Divide - A boundary on a potentiometric surface across which negligible groundwater flow occurs.

Groundwater Model - A mathematical simulation that represents the physical properties of the aquifer system. Groundwater models use discrete aquifer property estimates of an area to simulate, as closely as possible, the natural aquifer system. Groundwater models are often used as tools to evaluate changing conditions based upon natural or man-influenced situations.

Groundwater, Unconfined - Water within an aquifer that has a water table.

Hazardous Waste - Discarded material resulting from industrial, commercial, mining, or agricultural operations or from community activities that may pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. The term hazardous waste does not include materials that are specifically exempted from that classification.

Hydraulic Conductivity - A measure of the ease with which an aquifer transmits water. It varies according to the nature of the fluid and the material through which it is flowing.

Injection Well - A well through which fluids are introduced under pressure into the surrounding aquifer.

In-Lieu Recharge - An approach to recharging a depleted aquifer that supplies surface water to a groundwater user, when a surplus is available, to be used instead of groundwater. This allows the unused groundwater to remain in the basin to be used during times of need (see **conjunctive use**).

Long-Term Activity (as applied to the Groundwater Master Plan) - A management practice or technique to be used to guide the short-term activities that will be undertaken by the Water Department during the next 20 years.

Maximum Contaminant Level (MCL) - The highest concentration of a solute permissible in a public water supply as specified in the National Primary Drinking Water Standards under the Safe Drinking Water Act of 1974.

Monitoring Well - A well constructed for collecting data regarding groundwater conditions. Data that can be collected from monitoring wells include: (1) groundwater samples for evaluating water quality conditions, and (2) groundwater elevation measurements for assessing the movement of groundwater within an aquifer or the changes in the amount of water stored in the aquifer.

Memorandum of Understanding (MOU) - A formal means of documenting an agreement between two or more parties.

National Geodetic Vertical Datum of 1929 (NGVD) - A datum maintained by the U.S. Coast and Geodetic Survey that replaces Mean Sea Level.

Nonpotable - Water that is unsafe for human consumption without prior treatment but may have other beneficial uses such as irrigation, firefighting, toilet-flushing, wash water, and climate control.

Overdraft - The condition of a groundwater basin in which the amount of groundwater withdrawn under current development exceeds the amount of water that replenishes the basin over a period of time.

Porosity - A measure of the amount of void space in a volume of geologic material. The void portion of an aquifer is the space in which water is stored and through which groundwater flows.

Potable - Water that is safe for human consumption.

Potentiometric Surface - In confined or semiconfined aquifers, the imaginary surface representing the confined pressure (hydrostatic head) throughout all or part of the aquifer.

Production Well - A well that extracts groundwater for potable or nonpotable use.

Recharge - Any addition of water to the aquifer system such as rainfall, irrigation, pipe leakage, groundwater inflow, or infiltration from surface lakes or streams.

Saltwater-Freshwater Interface - The boundary between saline and fresh water.

Saltwater Intrusion - The movement of salt water into a body of fresh water. It can occur in either surface water or groundwater bodies.

San Francisco Water Supply - A series of reservoirs, aqueducts, and hydroelectric plants that capture and convey water from the Hetch Hetchy Reservoir on the Tuolumne River watershed and other surface water systems (such as the San Antonio and Calaverous Reservoirs) for direct delivery to customers and into San Francisco storage reservoirs. The system is owned by the City and County of San Francisco and is designed to provide up to 300 mgd to water users in the Bay Area and the City.

Saturated Zone - The zone below the water table where most of the pore spaces are occupied by water.

Short-Term Activity (as applied to the Groundwater Master Plan) - A specific action to be taken or study to be conducted during the next 5 years to begin to manage, develop, and use the City's groundwater.

Surface Water - Water that originates directly from streams, lakes, and reservoirs.

Time-of-Travel - A specified length of time for groundwater to travel to an active production well. It is dependent upon the aquifer properties (such as hydraulic conductivity) and the rate of pumping in the well.

Title 22 - California regulation that addresses water quality and water treatment issues for public water supply systems by establishing maximum concentrations of chemicals in water that pose no significant risk. The regulations also require that public water systems filter surface water and groundwater that is under the influence of surface water for microbiological contaminants.

Unsaturated Zone - The zone between the land surface and the water table where the majority of the pore spaces are occupied by air.

Water Table - The groundwater surface in an unconfined aquifer; the point at which groundwater occurs under atmospheric pressure.

Wellhead Protection Area (WHP Area) - The area delineated around a wellhead (or production well) to be protected from possible sources or causes of groundwater contamination.

Executive Summary

The San Francisco Water Department (Water Department) is responsible for providing a reliable, high quality, and affordable water supply for the City and County of San Francisco and its suburban wholesale customers. Surface water supplies from both the Hetch Hetchy Reservoir and local sources have provided most of the City's water supply for the past 60 years. Currently, the City is seeking methods to increase the reliability and security of its long-term water supply. By integrating the use of its potable surface water, potable and nonpotable groundwater, and nonpotable recycled water supplies, the City will continue to manage its water resources effectively.

The development of an integrated approach will respond to the water resources needs facing the City of San Francisco. Several of the needs are common to both the groundwater management program and the water recycling efforts of the Department of Public Works:

- **Bay Delta Hearings**. In the implementation of the new Bay Delta Water Quality Control Plan, the water needs of all urban and agricultural diverters from the Sacramento/San Joaquin River system are being evaluated and San Francisco, as well as other users, may need to give up some water supplies for environmental protection.

- **Water Supply Planning**. Recent studies conducted by the City have indicated that the safe yield of the Hetch Hetchy system has dropped from 300 mgd to 242 mgd. This has prompted the Water Department to look for alternative supplies to meet future water demands.

- **Continuing Drought**. Historically, California has experienced many multi-year droughts. During the 1986-92 drought, reservoir supplies became dangerously low and groundwater was overdrafted. Water conservation has been necessary for all businesses in the service area and mandatory rationing programs were in effect in San Francisco a majority of the time. Statewide, conjunctive use management of water resources was widely and successfully employed, providing the most water while still meeting the requirements of storage, transportation, and water quality standards. Using the groundwater resources more effectively and efficiently would produce more water in the long term, and protect against overdraft and degradation in the short term. Conjunctive use of groundwater, surface water, and recycled water will utilize these resources to the maximum extent practicable.

This Groundwater Master Plan (Master Plan) summarizes the Water Department's plans to evaluate, manage, and develop its groundwater resources and to integrate the potable and nonpotable use of groundwater for the benefit of its customers. The Master Plan identifies specific actions to be conducted by the Water Department during the next 5 years and outlines broader strategies for the next 20 years.

Total water demand in the City is expected to increase over the next 20 years as new higher-density buildings replace those destroyed by the 1989 Loma Prieta earthquake, as idle former military bases begin operating under new uses, as the public relaxes the stringent water-saving practices implemented during the recent drought, and as former industrial areas are revitalized. In 1994, approximately 5 percent of the City's average daily water demand was supplied by groundwater for nonpotable uses. The Water Department believes it may be possible to increase this percentage to help meet the City's growing water demands.

The City's use of groundwater will be increased by implementing a careful and planned approach. Five goals have been identified by the Water Department to frame its approach to managing, developing, and using the City's groundwater. These goals are as follows:

Goal 1: Protect and Enhance Groundwater Quality

Goal 2: Coordinate Groundwater Use

Goal 3: Protect and Conserve Related Water Resources

Goal 4: Improve Ability to Deliver Water During Emergencies

Goal 5: Maximize Groundwater Use

Goals 1, 2, and 3 focus on groundwater basin **management.** Solid groundwater management practices will provide the building blocks the Water Department needs to implement Goals 4 and 5, **development and use.** To formulate an overall approach to meet these five goals, the Water Department has identified long-term strategies to be implemented by conducting short-term activities. Strategies and activities for each goal are summarized in Tables ES-1 and ES-2.

Long-term strategies are those management practices and techniques the Water Department will use to meet the goals of its groundwater program. With the Water Department as the lead agency in managing the City's groundwater, short-term activities will be conducted over the next 5 years to manage, develop, and use the City's groundwater resources. San Francisco fully intends to develop comprehensive groundwater management programs to meet the water resources needs and obligations of the 21st century. The lessons learned and the success of the City's efforts will set an example that will encourage its wholesale customers to implement similar programs. These activities include, but are not limited to, the following:

- Form interjurisdictional committees to manage a common groundwater resource
- Form a Groundwater Management Unit within the Water Department to be a technical resource for information about the City's groundwater and to implement the City's groundwater program
- Develop and implement a groundwater monitoring program to protect and manage groundwater quality
- Continue and improve monitoring the potential for saltwater intrusion because of increased groundwater use
- Develop a wellhead protection program to protect the quality of groundwater within the City's basins

Table ES-1

Summary of the Water Department's Goals, Long-Term Strategies, and Short-Term Activities for
GROUNDWATER MANAGEMENT

Goal	Long-Term Strategy	Short-Term Activity
1. Protect and Enhance Groundwater Quality	1A Prevent saltwater intrusion	1A1 Evaluate potential for saltwater intrusion 1A2 Develop and implement a saltwater intrusion prevention network
	1B Reduce risk of future groundwater contamination	1B1 Develop and implement a wellhead protection program
	1C Increase hydrologic data regarding City's groundwater resource	1C1 Develop and implement a groundwater monitoring program
2. Coordinate Groundwater Use	2A Establish Water Department as lead in City groundwater management	2A1 Establish a Groundwater Management Unit within the Water Department
	2B Improve coordination with other government agencies regulating/affecting groundwater use within the City	2B1 Form a City groundwater management committee
	2C Improve coordination with adjacent entities whose groundwater use affects shared groundwater basins	2C1 Form appropriate AB 3030 management committee(s)
	2D Enhance communication with Water Department customers	2D1 Develop and implement a public information program
3. Protect and Conserve Related Water Resources	3A Manage lake water levels	3A1 Conduct additional field investigation at Lake Merced 3A2 Conduct modeling to estimate effects of specific groundwater pumping patterns on Lake Merced water levels 3A3 Evaluate relationship between other City lakes and groundwater 3A4 Develop and implement policies and procedures to manage water levels in City lakes
	3B Manage stream water levels	3B1 Assess effects of groundwater development on Lobos Creek 3B2 Evaluate relationship between other City streams and groundwater 3B3 Develop and implement procedures to manage water levels in City streams

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Table ES-2
Summary of the Water Department's Goals, Long-Term Strategies, and Short-Term Activities for
GROUNDWATER DEVELOPMENT AND USE

Goal	Long-Term Strategy	Short-Term Activity
4. Improve Ability to Deliver Water During Emergencies	4A Evaluate use of groundwater as an emergency reserve	4A1 Study the feasibility of installing large-capacity standby wells 4A2 Design, install and operate large-capacity standby wells, if appropriate 4A3 Update the Water Department's Emergency Operations Plan
5. Maximize Groundwater Use	5A Capture groundwater outflow to the San Francisco Bay or Pacific Ocean	5A1 Extract groundwater from Elk Glen Well; add to main distribution system 5A2 Extract groundwater from the Sunset District, add to main distribution system
	5B Capture groundwater produced by dewatering operations	5B1 Add groundwater to the AWSS from dewatering at the Powell Street BART 5B2 Identify permanent dewatering operation in the City and identify potential beneficial uses for the water 5B3 Develop procedures to put temporary construction dewatering water to beneficial use 5B4 Evaluate the feasibility of using, and implement if appropriate, the existing sludge line to convey non-potable water to the North Point plant
	5C Operate groundwater basins conjunctively	5C1 Conduct in-lieu recharge of the southern portion of the Westside Basin 5C2 Conduct conjunctive use in the Lobos Basin
	5D Investigate other groundwater basins	5D1 Develop and implement a study of the Lobos Basin 5D2 Develop and implement studies of other shared and City basins
	5E Evaluate other potential activities for increasing groundwater use	5E1 Evaluate, and implement where feasible, potential groundwater use in the City's fountains and decorative pools 5E2 Evaluate, and implement where feasible, the potential for groundwater to help control corrosion in the City's water distribution system

117808.08.ZZ Table ES-2(9/95 revision) 9-15-95sbm

- Collect and analyze additional hydrogeologic information at Lake Merced, evaluate alternative groundwater management practices, and implement the selected alternative(s) to help restore Lake Merced water levels
- Identify potential conjunctive use opportunities to use the local groundwater basins to store surplus surface water or to retain existing groundwater for use during times of need
- Evaluate the interaction of existing surface water bodies and groundwater to assess potential impacts from increased groundwater use

- Identify the potential development of groundwater resources within the City's groundwater basins to evaluate the potential quantity and quality of groundwater available to the City
- Identify potential uses for groundwater, including emergency supply, potable supply, and nonpotable supply to develop efficient and beneficial management of the City's water resources
- Retrofit or install wells from which groundwater could be pumped and supplied to City customers

An initial screening based on preliminary evaluations of water quality, supply potential, and current groundwater use were done to determine that these three basins would have the highest potential for groundwater development. Some policies and procedures, such as wellhead protections, will apply to all seven basins, but further evaluations of the other four basins will be done in another phase of this Master Plan.

The Water Department will implement management activities and short-term development and use activities in a coordinated manner during the next several years. Figures ES-1 and ES-2 show the proposed schedule for implementing the short-term activities.

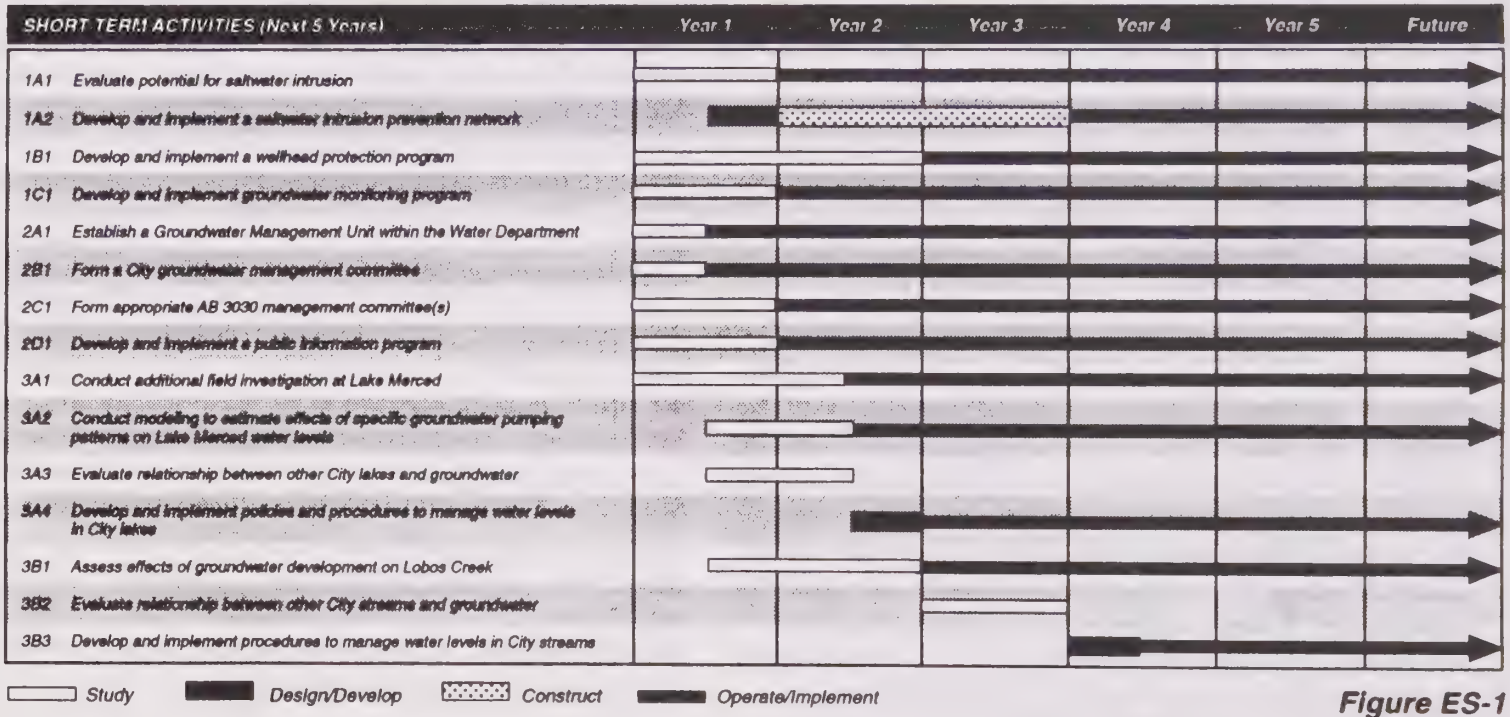

Figure ES-1
Implementation Schedule for Short-Term Groundwater Management Activities

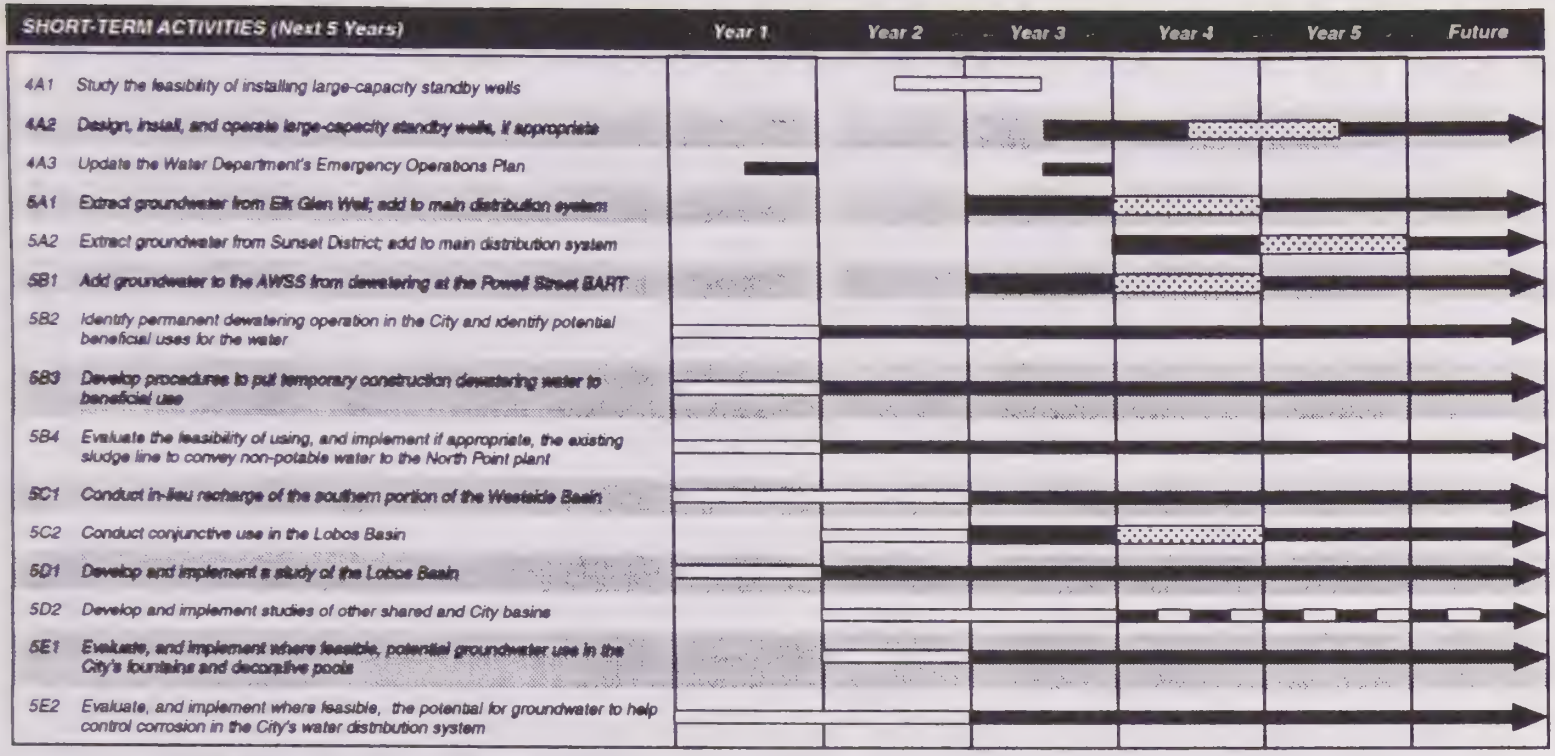

Figure ES-2
Implementation Schedule for Short-Term Groundwater Development and Use Activities

As stated previously, the activities described in this Master Plan will be implemented on a 5-year schedule with the strategies and goals providing the conceptual framework for the City's groundwater management, development, and use over the next 20 years. In addition, activities conducted during implementation of this Master Plan will provide guidance for specific activities to be identified and conducted in the future. Future activities will be evaluated by the public and reviewed for potential environmental impacts following procedures similar to those used for this Master Plan.

The total cost of funding each of the short-term activities for the next 5 years is estimated to be $7.37 million (assuming 1995 dollars in year 1 and a 4 percent inflation factor during each of the subsequent 4 years). This includes capital costs of $4.93 million and $2.44 million of total annual operation and maintenance (O&M) costs at full implementation of this Master Plan (in year 5). Table ES-3 summarizes the annual capital costs and O&M costs projected for each of the five Master Plan goals. Actual costs may vary, however, pending final City review, approval, and funding.

Table ES-3
Projected Annual Capital and O&M Costs for Short-Term Activities

	Short-Term Implementation Period									
	Year 1		Year 2		Year 3		Year 4		Year 5	
	Capital Costs	O&M Costs	Capital Costs	O&M Costs	Capital Costs	O&M Costs	Capital Costs	O&M Costs	Capital Costs	O&M Costs
Management Activities										
Goal 1	$1,040,000	$0	$54,100	$161,200	$30,300	$167,600	$0	$174,400	$0	$181,300
Goal 2	$42,000	$0	$36,400	$0	$21,600	$252,000	$0	$262,100	$0	$272,500
Goal 3	$295,000	$0	$104,000	$0	$10,800	$0	$0	$0	$0	$0
Development and Use Projects										
Goal 4	$14,000	$0	$20,800	$0	$255,200	$0	$255,200	$281,200	$255,200	$292,500
Goal 5	$293,000	$0	$140,200	$0	$260,600	$0	$1,378,400	$0	$425,100	$396,500
Annual Capital Costs	**$1,684,000**		**$355,500**		**$578,500**		**$1,633,600**		**$680,300**	
Annual O&M Costs		**$0**		**$161,200**		**$419,600**		**$717,700**		**$1,142,800**
Annual Costs	**$1,684,000**		**$516,700**		**$998,100**		**$2,351,300**		**$1,823,100**	

Notes:
1) It is assumed that the City will use revenue bonds to finance all individual projects over $2.5 million. Therefore, the annual debt service payments are included here for projects 4A1 and 5A2, which assume that issuance costs and reserve requirements will add 15 percent to the principal on these bonds.
2) It is assumed that the City will fund all O&M costs of short-term activities from annual operating budgets.
3) Costs include inflation, which is assumed to be 4 percent per year.

The groundwater program will be financed with the Water Department's routine capital improvement fund and revenue bonds. The cost of groundwater produced by the currently identified activities that generate water ranges from $206 to $526 per acre-foot. These costs compare favorably with the surface water supply cost of $450 per acre-foot and support the City's commitment to providing reliable, affordable, and high quality water for its customers.

Section One - Introduction

The San Francisco Water Department is responsible for providing a reliable, high-quality, and affordable water supply for the City of San Francisco. Surface water supplies from both the Hetch Hetchy Reservoir and local sources have been able to meet the City's water supply needs for the past 60 years. However, during the recent prolonged drought, the City faced considerable water shortage impacts due to limitations in the system. To reduce future water shortage impacts, the Water Department is seeking methods to increase the reliability of its long-term supply. By integrating the use of its surface water, groundwater, and recycled water and continuing its conservation efforts, the City will continue to manage its water resources effectively.

Groundwater was an important component of the City of San Francisco's (the City) water supply during the City's development. The water used by early City residents was primarily obtained from lakes and flowing springs. As its water needs grew, the City became increasingly dependent on local surface water and groundwater. By 1913, the City of San Francisco estimated that it was using approximately 8.5 million gallons of groundwater per day (Bartell, 1913) from private and City wells, springs, and Lobos Creek (which is fed by groundwater). This amount constituted approximately 13 percent of the City's total water use (Freeman, 1912). After completion of the Hetch Hetchy Reservoir in 1934, the use of groundwater within the City decreased.

Since the early 1900s, the City has undergone major changes: it has become a dense urban center with a population exceeding 700,000, it has acquired rights to surface water from outside its limits, and it now owns and operates the citywide water distribution system. In addition, the federal government has promulgated water quality standards to reduce the threat to the public from waterborne diseases. These changes have influenced groundwater use in the City, estimated from Water Department records to be approximately 4 million gallons per day (mgd) in 1994 (not including dewatering operations) or about 5 percent of total potable demand. Most of this groundwater is produced and used by two entities, the San Francisco Recreation and Park Department and the Presidio (operated by the National Park Service since 1994; prior to which it was operated by the U.S. Army).

Board of Supervisors Ordinances

In 1991, the City's Board of Supervisors passed Article 22, the Recycled Water Use Ordinance (Ord. 390-91 and 391-91). This ordinance mandated the development of groundwater and recycled water for maximum beneficial use wherever reasonable. A number of events were driving forces behind the ordinance, including the fifth year of a 6-year drought in Northern California. The ordinance followed several earlier resolutions (389-89, 612-91) that recommended expanded use of groundwater

and surface water and that agreed with the Water Department's mission: "To manage limited water sources through conservation of potable water and use of nonpotable water to meet nonpotable demand."

In accordance with the requirement to develop recycled water and groundwater, the Recycled Water Use Ordinance mandated the following actions:

- The Water Department should prepare a Groundwater Master Plan detailing groundwater development.
- The San Francisco Department of Public Works (Department of Public Works) should prepare a Recycled Water Master Plan detailing recycled water development.
- These plans should be coordinated to help expand the use of groundwater and recycled water by all water consumers in San Francisco.

The Water Department and the Department of Public Works are currently working together to meet the Board of Supervisors' requirements.

As shown in Figure 1-1, the final Groundwater and Recycled Water Master Plans will move forward together into environmental review, during 1995-1996. This environmental impact report (EIR), as currently envisioned, will take place on two levels: (1) the programmatic level, which is global and policy-oriented; and (2) the project level, which is activity-specific. As part of the programmatic EIR, project-specific EIRs will be conducted as required. Additionally, short-term activities identified during implementation of the Master Plans may or may not require project EIRs. After completion of the programmatic EIR, the coordinated implementation of the groundwater and recycled water programs will be overseen by the Water Department and Department of Public Works, respectively.

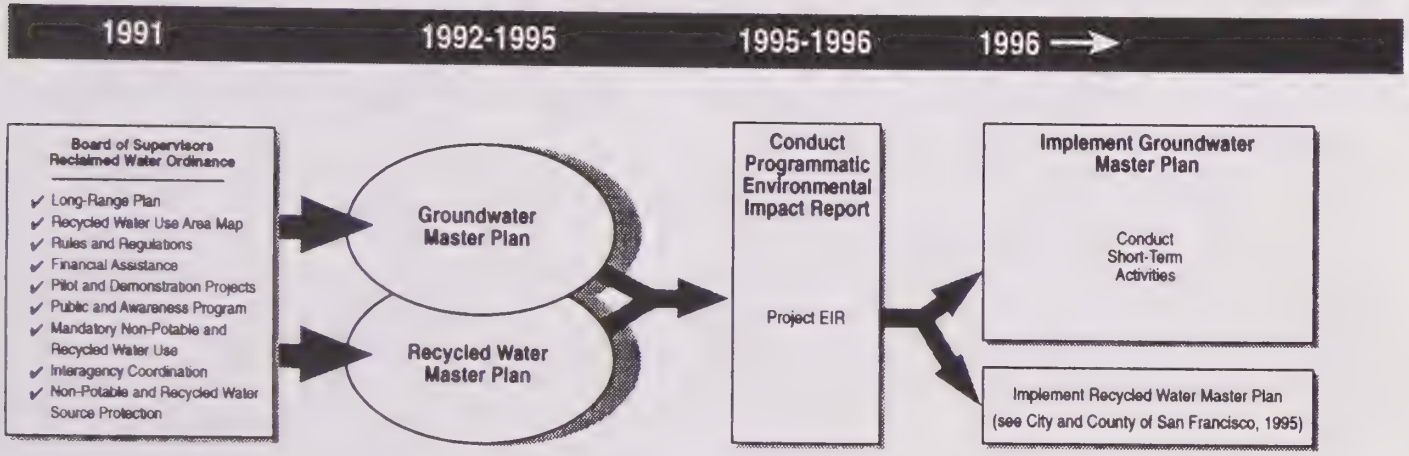

Figure 1-1
Groundwater and Recycled Water Programs

Groundwater Master Plan Overview

This Groundwater Master Plan (Master Plan) summarizes the Water Department's plans to evaluate, manage, and develop its groundwater resources and to integrate the use of groundwater for the benefit of Water Department customers (Figure 1-2). It identifies specific activities for the Water Department to conduct during the next 5 years and outlines broader strategies for the next 20 years. The flexible schedule for conducting the proposed actions can be modified if the needs of the Water Department change or findings of the planned activities warrant.

Incorporating groundwater into the City's overall water management strategy is a complex undertaking for the following reasons:

- The hydrogeologic complexity and diversity of the City's groundwater basins may prevent uniform application of approaches to groundwater management and use throughout the City.
- In some areas hydrogeologic information is not sufficient for evaluating local groundwater resources.
- Several of the basins are shared with other political entities, necessitating additional coordination and planning.
- Environmental concerns, such as induced saltwater intrusion and impacts on local lakes and groundwater levels, may be associated with increased groundwater use.
- Several areas within the City are known to have poor groundwater quality; the extent of such groundwater and its potential impacts on water uses must be assessed.
- The City plans to increase its use of recycled water within the next 10 years. Increased groundwater use will be coordinated with the use of recycled and surface water.

The Master Plan is intentionally broad in scope to address this wide range of issues and to provide flexibility to the City in meeting its variable water supply and water demands. The Master Plan identified the goals, long-term strategies, and short-term activities developed by the Water Department to incorporate groundwater into the City's overall water management strategy. The Water Department defines goals, long-term strategies, and short-term activities as follows:

Goals: The Water Department's ultimate purpose in managing, developing, and using local groundwater.

Long-Term Strategies: Management practices and techniques to guide activities to be implemented over the next 20 years toward meeting those goals.

Short-Term Activities: Specific activities to be conducted within the next 5 years to begin management, development, and use of groundwater. These include both constructible projects and program development, as well as additional studies to define subsequent activities.

Figure 1-2
Integration of Surface Water, Groundwater, and Recycled Water to Meet the Needs of San Francisco Water Department Customers

Tables 1-1 and 1-2 identify the goals, long-term strategies, and short-term activities developed by the Water Department. These tables also show which short-term activity is related to which long-term strategy, and subsequently to which goal. However, the goals, strategies, and activities of this Master Plan are interrelated—information and results from one activity may be used to complete other activities—and will be implemented to maximize this relationship.

Table 1-1
Summary of the Water Department's Goals, Long-Term Strategies, and Short-Term Activities for
GROUNDWATER MANAGEMENT

Goal	Long-Term Strategy	Short-Term Activity
1. Protect and Enhance Groundwater Quality	1A Prevent saltwater intrusion	1A1 Evaluate potential for saltwater intrusion 1A2 Develop and implement a saltwater intrusion prevention network
	1B Reduce risk of future groundwater contamination	1B1 Develop and implement a wellhead protection program
	1C Increase hydrologic data regarding City's groundwater resource	1C1 Develop and implement a groundwater monitoring program
2. Coordinate Groundwater Use	2A Establish Water Department as lead in City groundwater management	2A1 Establish a Groundwater Management Unit within the Water Department
	2B Improve coordination with other government agencies regulating/affecting groundwater use within the City	2B1 Form a City groundwater management committee
	2C Improve coordination with adjacent entities whose groundwater use affects shared groundwater basins	2C1 Form appropriate AB 3030 management committee(s)
	2D Enhance communication with Water Department customers	2D1 Develop and implement a public information program
3. Protect and Conserve Related Water Resources	3A Manage lake water levels	3A1 Conduct additional field investigation at Lake Merced 3A2 Conduct modeling to estimate effects of specific groundwater pumping patterns on Lake Merced water levels 3A3 Evaluate relationship between other City lakes and groundwater 3A4 Develop and implement policies and procedures to manage water levels in City lakes
	3B Manage stream water levels	3B1 Assess effects of groundwater development on Lobos Creek 3B2 Evaluate relationship between other City streams and groundwater 3B3 Develop and implement procedures to manage water levels in City streams

117808 08.ZZ Table 1-1(9/95 revision) 9-15-95abm

Table 1-2
Summary of the Water Department's Goals, Long-Term Strategies, and Short-Term Activities for
GROUNDWATER DEVELOPMENT AND USE

Goal	Long-Term Strategy	Short-Term Activity
4. Improve Ability to Deliver Water During Emergencies	4A Evaluate use of groundwater as an emergency reserve	4A1 Study the feasibility of installing large-capacity standby wells 4A2 Design, install and operate large-capacity standby wells, if appropriate 4A3 Update the Water Department's Emergency Operations Plan
5. Maximize Groundwater Use	5A Capture groundwater outflow to the San Francisco Bay or Pacific Ocean	5A1 Extract groundwater from Elk Glen Well; add to main distribution system 5A2 Extract groundwater from the Sunset District, add to main distribution system
	5B Capture groundwater produced by dewatering operations	5B1 Add groundwater to the AWSS from dewatering at the Powell Street BART 5B2 Identify permanent dewatering operation in the City and identify potential beneficial uses for the water 5B3 Develop procedures to put temporary construction dewatering water to beneficial use 5B4 Evaluate the feasibility of using, and implement if appropriate, the existing sludge line to convey non-potable water to the North Point plant
	5C Operate groundwater basins conjunctively	5C1 Conduct in-lieu recharge of the southern portion of the Westside Basin 5C2 Conduct conjunctive use in the Lobos Basin
	5D Investigate other groundwater basins	5D1 Develop and implement a study of the Lobos Basin 5D2 Develop and implement studies of other shared and City basins
	5E Evaluate other potential activities for increasing groundwater use	5E1 Evaluate, and implement where feasible, potential groundwater use in the City's fountains and decorative pools 5E2 Evaluate, and implement where feasible, the potential for groundwater to help control corrosion in the City's water distribution system

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Tables 1-3 and 1-4 provide summaries of the short-term activities applicable to each groundwater basin within the City.

The goals, strategies, and activities are discussed below and in detail in Sections 3 through 8 of this Master Plan.

Table 1-3
Relationship of Groundwater Management Short-Term Activities to Groundwater Basins

Short-Term Activities	Groundwater Basin: Downtown	Islais Valley	Lobos	Marina	South	Visitacion Valley	Northern Portion of Westside	Southern Portion of Westside
1A1 Evaluate potential for saltwater intrusion			●				●	
1A2 Develop and implement saltwater intrusion prevention network							●	
1B1 Develop and implement a wellhead protection program	●	●	●	●	●	●	●	
1C1 Develop and implement groundwater monitoring program	●	●	●	●	●	●	●	
2A1 Establish a Groundwater Management Unit within the Water Department	●	●	●	●	●	●	●	
2B1 Form a City groundwater management committee	●	●	●	●	●	●	●	
2C1 Form appropriate AB 3030 management committee(s)		●	●	●		●	●	●
2D1 Develop and implement a public information program	●	●	●	●	●	●	●	
3A1 Conduct additional field investigation at Lake Merced							●	●
3A2 Conduct modeling to estimate effects of specific groundwater pumping patterns on Lake Merced water levels							●	●
3A3 Evaluate relationship between other City lakes and groundwater			●				●	
3A4 Develop and implement policies and procedures to manage water levels in City lakes			●				●	●
3B1 Assess effects of groundwater development on Lobos Creek			●					
3B2 Evaluate relationship between other City streams and groundwater	●	●	●	●			●	
3B3 Develop and implement procedures to manage water levels in City streams	●	●	●	●			●	

Table 1-4
Relationship of Groundwater Development and Use Short-Term Activities to Groundwater Basins

Short-Term Activities	Groundwater Basin							
	Downtown	Islais Valley	Lobos	Marina	South	Visitacion Valley	Northern Portion of Westside	Southern Portion of Westside
4A1 Study the feasibility of installing large-capacity standby wells	●	●	●	●	●	●	●	
4A2 Design, install, and operate large-capacity standby wells, if appropriate	●	●	●	●	●	●	●	
4A3 Update the Water Department's Emergency Operations Plan	●	●	●	●	●	●	●	
5A1 Extract groundwater from Elk Glen Well; add to main distribution system							●	
5A2 Extract groundwater from the Sunset District, add to main distribution system							●	
5B1 Add groundwater to the AWSS from dewatering at the Powell Street BART	●							
5B2 Identify permanent dewatering operation in the City and identify potential beneficial uses of the water	●	●	●	●	●	●	●	
5B3 Develop procedures to put temporary construction dewatering water to beneficial use	●	●	●	●	●	●	●	
5B4 Evaluate the feasibility of using, and implement if appropriate, the existing sludge line to convey non-potable water to the North Point plant	●							
5C1 Conduct in-lieu recharge of the southern portion of the Westside Basin								●
5C2 Conduct conjunctive use in the Lobos Basin			●					
5D1 Develop and implement a study of the Lobos Basin			●					
5D2 Develop and implement studies of other shared and City basins		●		●	●	●		
5E1 Evaluate, and implement where feasible, potential groundwater use in the City's fountains and decorative pools	●	●	●	●	●	●	●	
5E2 Evaluate, and implement where feasible, the potential for groundwater to help control corrosion in the City's water distribution system	●	●	●	●	●	●	●	

Goals

Groundwater in the groundwater basins must be protected and carefully managed to be effective as a long-term resource. To emphasize the importance of this management, the Water Department has established three groundwater management goals:

- *Goal 1*: Protect and Enhance Groundwater Quality
- *Goal 2*: Coordinate Groundwater Use
- *Goal 3*: Protect and Conserve Related Water Resources

Once a framework for long-term management of the groundwater basins has been established, the Water Department anticipates that groundwater can be strategically developed and used. Therefore, the Water Department has two development and use goals:

- *Goal 4*: Improve Ability to Deliver Water During Emergencies
- *Goal 5*: Maximize Groundwater Use

Implementation of these Water Department goals will be coordinated to achieve successful implementation of the Master Plan (Figure 1-3).

Long-Term Strategies

Long-term strategies, which have a time frame of up to 20 years, are broad in scope to allow for flexibility so they can be updated as new information becomes available. In some cases, additional short-term activities will be needed to achieve the long-term strategy. Long-term strategies are relatively specific for the Westside and Downtown Basins and are more general for the other basins where there are insufficient data to support more specific strategies.

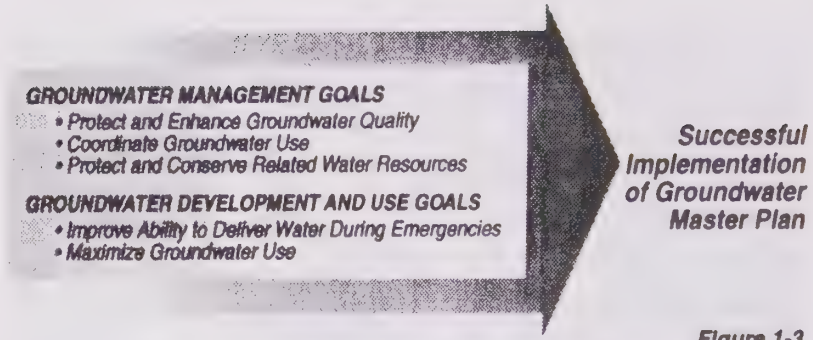


Figure 1-3
Groundwater Master Plan Goals

Short-Term Activities

Short-term activities will be conducted or initiated by the Water Department within the next 5 years to move toward managing, developing, and using City groundwater within the framework of the goals and strategies outlined above. Short-term activities include constructible projects (such as the Sunset District wells), development of programs (wellhead protection program), and identification of additional studies (Lobos Basin). Additional studies are recommended in some situations to provide the City sufficient information for its decisions regarding groundwater management, development, and use.

Groundwater Master Plan Organization

The remainder of this document is organized as follows:

Section 2: Background information on the City's water resources

Sections 3-7: Discussions of the goals, long-term strategies, and short-term activities that constitute the City's groundwater program

Section 8: Summary of capital and operation and maintenance costs, and the likely implementation schedule and funding sources for the short-term activities

Section Two - San Francisco Water Resources

Seven groundwater basins occur beneath the City of San Francisco: the Westside, Lobos, Marina, Downtown, Islais Valley, South, and Visitacion Valley Basins (Figure 2-1). Designation of the groundwater basins within the Master Plan follows the U.S. Geological Survey (USGS) description of "a contiguous body of unconsolidated sediments and the surrounding surface drainage area" (Phillips et al., 1993). The Lobos, Marina, Downtown, and South Basins are contained wholly within the limits of the City (City boundaries are shown in Figure 4-2). The Islais Valley Basin extends beneath Daly City, Visitacion Valley Basin extends beneath the City of Brisbane, and the Westside Basin extends south of the City across several political boundaries (the Cities of Daly City, Colma, South San Francisco, San Bruno, and Millbrae) past the San Francisco International Airport. Groundwater demands within the Westside Basin vary; thus, the Master Plan references the northern portion of the Westside Basin (north of the City boundary) and the southern portion of the Westside Basin (south of the City boundary) to help distinguish between the groundwater beneath the City and County of San Francisco and the groundwater that is physically connected to, but located beneath land outside the City limits.

Section 2 summarizes the City's water supply and demand, existing water supply systems, and groundwater resources.

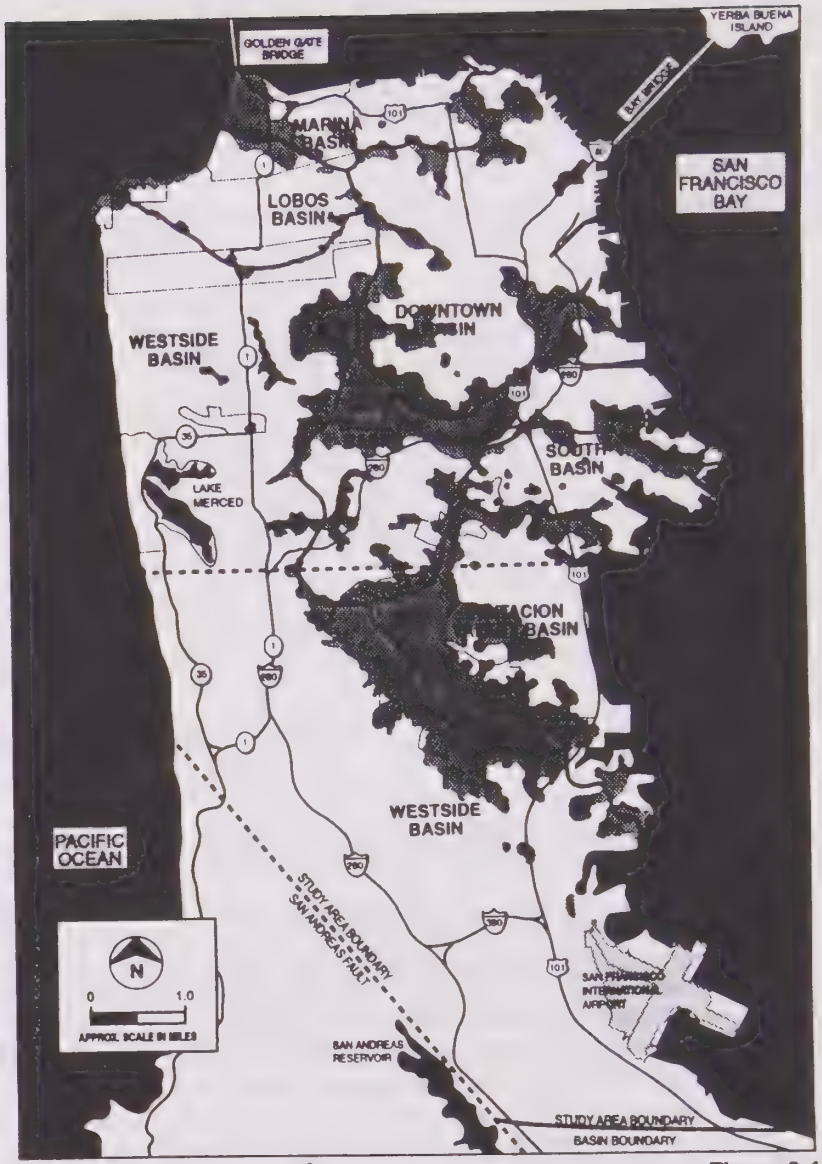


Figure 2-1
Groundwater Basins Within and Adjacent to the City of San Francisco

Historical, Current, and Projected Future Water Supply and Demand

Historical and projected future water supply and demand for both the City and the area south of the City appear in Table 2-1. Changes in water use in the Westside Basin from 1970 to 1994 by users of both groundwater and surface water supplies are shown in Figure 2-2.

Table 2-1
Estimated Historical and Projected Water Use
(average day in mgd)

Groundwater Basin	FY 1970[a,b,c]			FY 1980[a,b,c]			FY 1990[a,b,c]			FY 1994[a,b,c,d]			2000[e,f]	2010[e,f]
	Surface Water	Ground-water[g]	Total	Surface Water	Ground-water[g]	Total	Surface Water	Ground water[g]	Total	Surface Water	Ground water[g]	Total	Total	Total
Westside (northern portion)	19.8	2	21.8	15.5	2	17.5	13.8	2	15.8	13.1	2	15.1	--	--
Lobos	6.5	2	8.5	5.1	2	7.1	4.5	2	6.5	4.4	2	6.4	--	--
Marina	8.3	0	8.3	6.5	0	6.5	5.8	0	5.8	5.1	0	5.1	--	--
Downtown	53.7	0	53.7	42.1	0	42.1	37.2	0	37.2	34.9	0	34.9	--	--
Islais Valley	15.7	0	15.7	12.3	0	12.3	10.9	0	10.9	10.2	0	10.2	--	--
South	5.4	0	5.4	4.2	0	4.2	3.7	0	3.7	3.6	0	3.6	--	--
Visitacion Valley	1.9	0	1.9	1.5	0	1.5	1.3	0	1.3	1.5	0	1.5	--	--
Total City	**111.3**	**4**	**115.3**	**87.2**	**4**	**91.2**	**77.1**	**4**	**81.1**	**72.8**	**4**	**76.8**	**103**	**105**
Westside (southern portion)[h]	15.9	7.3	23.2	14.1	6.6	20.7	13.5	5.4	18.9	13.8	6.8	20.6	25.1	25.1
Total All Basins	**127.2**	**11.3**	**138.5**	**101.3**	**10.6**	**111.9**	**90.6**	**9.4**	**100.0**	**86.6**	**10.6**	**97.2**	**128.1**	**130.1**

[a]Estimates are for City fiscal year (FY) that runs from July 1 to June 30.
[b]Sources of in-City estimates are Bookman-Edmonston Engineering (1992), SFWD City Distribution Division, and Pitometer Associates (1961-1989).
[c]Source of outside-City estimates are Bay Area Water Users Association, Cities of San Bruno and Daly City, California Water Service, and SFWD.
[d]1994 demand numbers reflect the results of mandatory conservation required by City Ordinances 185-91, 346-91, and 359-91.
[e]Source of in-City estimates is the Response to Data Request Concerning FERC Opinion 4210 (City and County of San Francisco, 1993).
[f]Estimates include groundwater use projected to be the same as FY 1994, including 2-mgd demand met by NPS' diversion from Lobo Creek.
[g]Only known active wells producing a significant amount of groundwater are included as groundwater demand. Dewatering operations are not included.
[h]Includes water suppliers with both groundwater and surface water supplies only (Cities of San Bruno and Daly City and California Water Service, South San Francisco) and the San Francisco International Airport.

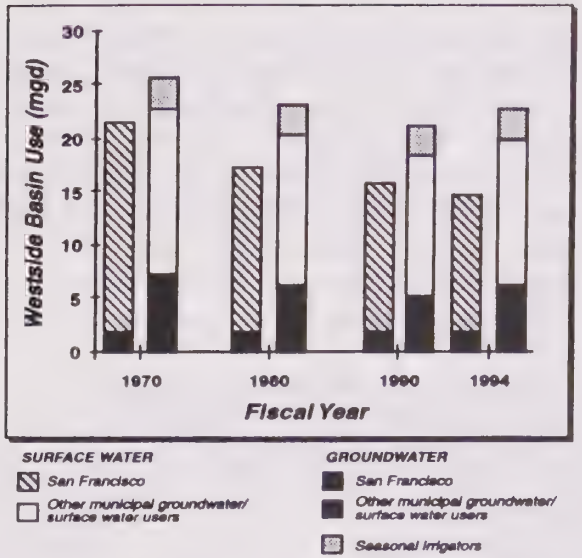
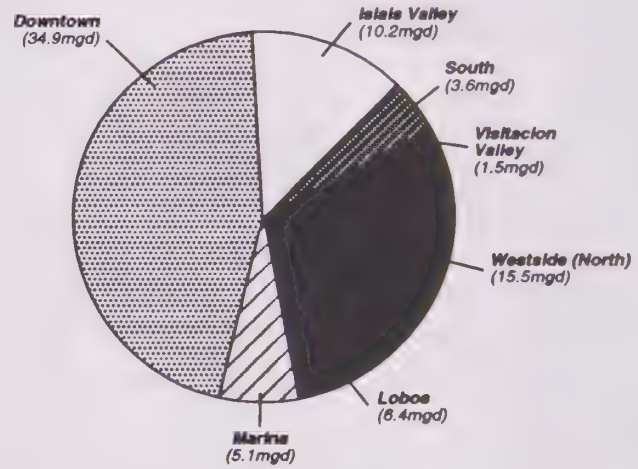


Figure 2-2
Average Daily Water Use by Groundwater Users in the Westside Basin

On an average day in 1994, an estimated 76.8 mgd of water was used in the City, 72.8 mgd of surface water and 4 mgd of groundwater. This is significantly less than total water use in 1980 (91.2 mgd) and 1970 (115.3 mgd). A number of factors, including decline in industrial water use, the loss of buildings from the 1989 Loma Prieta earthquake, recent military base closures (e.g., Hunters Point), and the 1976-1977 and 1987-1992 droughts, have contributed to the recent decline in water demand (and hence, supply). As projected by the Public Utilities Commission (City and County of San Francisco, 1993), the average day demand is expected to rise by the year 2000 to approximately 110 mgd as new high-density buildings are constructed on the sites of those destroyed by the Loma Prieta earthquake, as new uses are introduced on the sites of former military bases, as the public relaxes the strict water-saving practices in place during the 1987-1992 drought, and as former industrial areas are revitalized. As shown in Table 2-1, 1994 City water demand is highest in the northern portion of the Westside and Downtown Basins. The distribution of City water demand in 1994 by groundwater basin appears in Figure 2-3.



Data are from Water Department Records

Figure 2-3
FY 1994 Average Annual City Water Demand (by Groundwater Basin)

FY1994 total water demand by municipal users of groundwater within the southern portion of the Westside Basin (Cities of San Bruno, Daly City, and South San Francisco, supplied by California Water Service) and the San Francisco International Airport was approximately 20.4 mgd (13.8 mgd of surface water and 6.6 mgd of groundwater). In 1991, an additional estimated 3 mgd (a rate that is assumed to be continuing) of nonmunicipal groundwater was used seasonally for irrigation of private golf courses and cemeteries (shown in Figure 2-4).

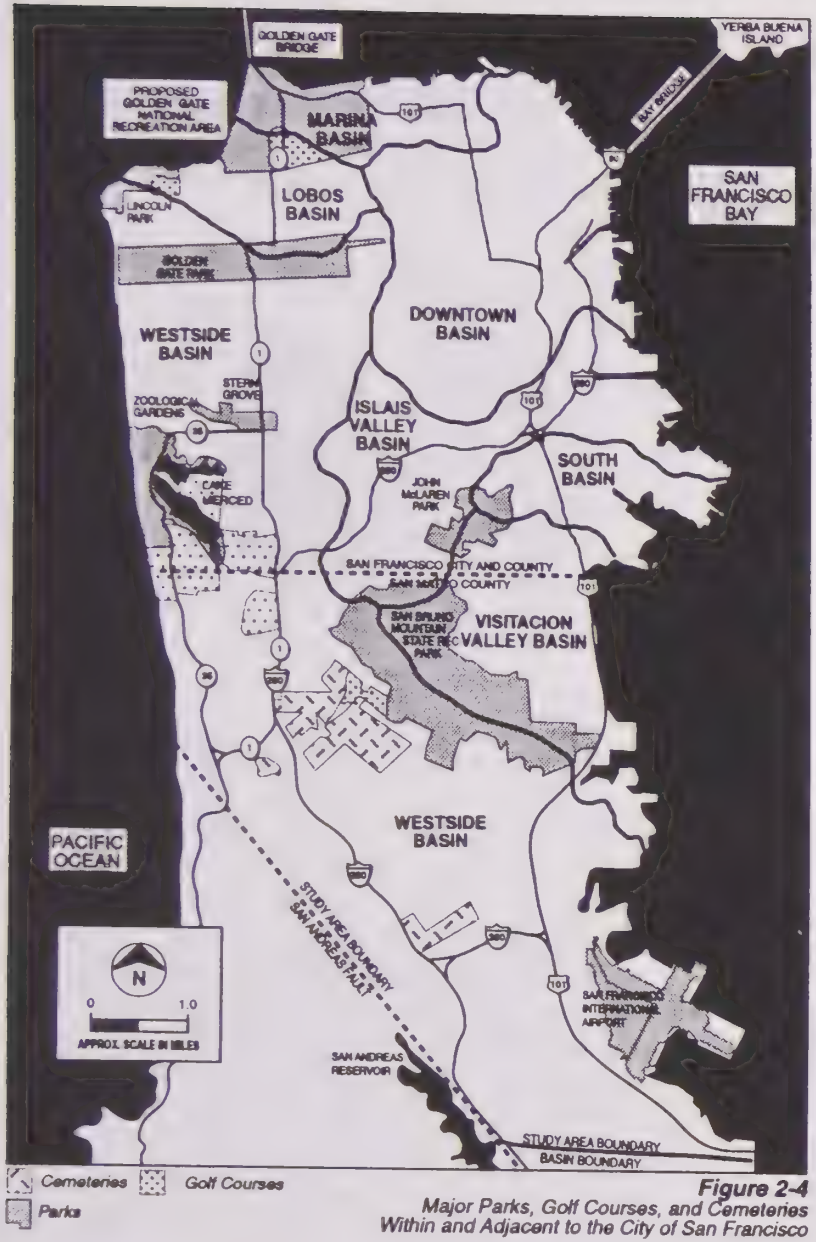


Figure 2-4
Major Parks, Golf Courses, and Cemeteries Within and Adjacent to the City of San Francisco

The 20.4-mgd total water demand (surface and groundwater) in 1994 by groundwater users in the southern portion of the Westside Basin has increased from the 1990 level of 18.9 mgd and is similar to the 20.7-mgd demand in 1980. The decrease in total water demand from 1970 to 1990 can be attributed to the same factors that have affected the City's water demand. Projected future demand in the southern portion of the Westside Basin is expected to increase to 25.1 mgd by 2000.

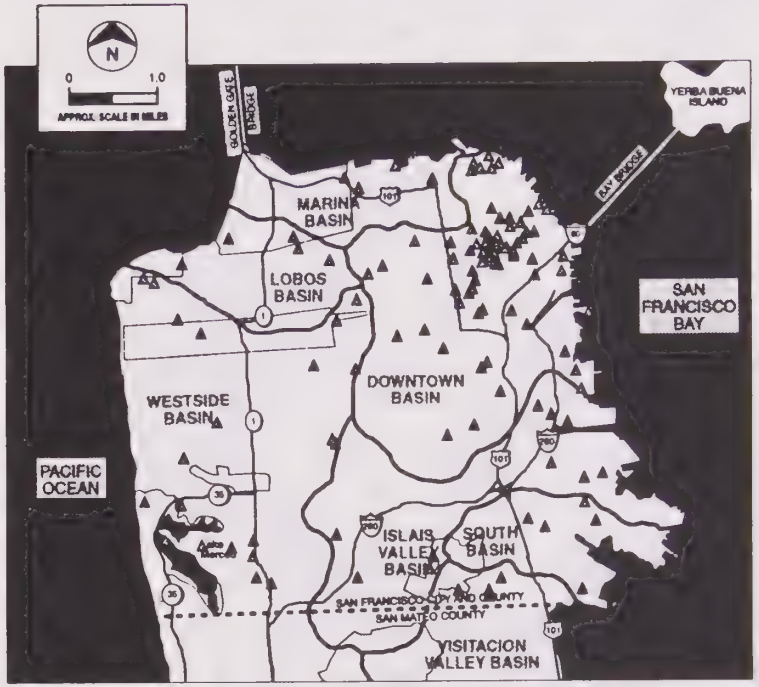
Location of In-City Water Demand

The most economical way to use groundwater is to serve the largest demand, or combination of demands, with the fewest possible wells pumping at full capacity. City groundwater can be used to meet demands for potable and nonpotable water. The Water Department identified potential potable water users and worked with the Department of Public Works to identify potential nonpotable users, or groups of users, that could be served with groundwater.

The Water Department began by identifying and locating the large potable water users. For the purposes of this Master Plan, large potable users (Figure 2-5) are those using more than 10 acre-feet of water per year (the equivalent of approximately 9,000 gallons per day). As Figure 2-5 shows, large water users are concentrated within the downtown commercial area. The Water Department currently serves most of these large water users with surface water, except for Recreation and Park

Department facilities, several golf courses in the Lake Merced area, the zoo, and the Presidio. These exceptions are, in part, served by groundwater.

In the Recycled Water Master Plan, the Department of Public Works identified potential nonpotable water users within the City as those using water primarily for irrigation (Figure 2-6). The largest of these are the large parks and golf courses in the northern portion of the Westside Basin. Smaller potential nonpotable water users include schools, playgrounds, and smaller neighborhood parks throughout the City.



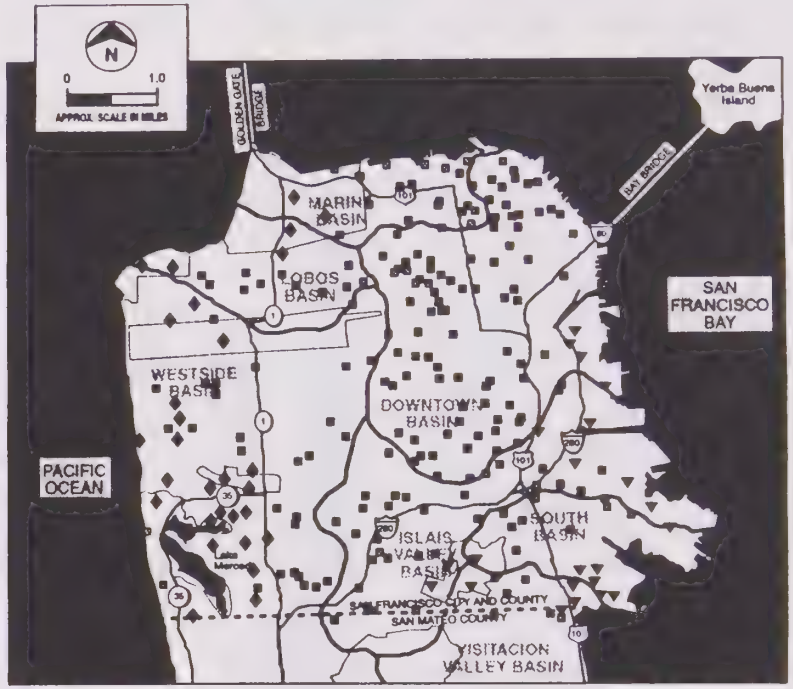
▲ = Major Groundwater User

▲ = Major Surface Water User

NOTE: Large users are those users identified from Water Department records who use more than 10 acre-feet (3.26 million gallons) of water per year.

Sources: San Francisco Water Department, City Distribution Division, Pitometer Associates (1961-1989)

Figure 2-5
Location of Large Potable Water Users



Parks (see Fig. 2-4 for names)

◆ Users scheduled to be provided with recycled water during Phase 1 of the Recycled Water Master Plan (1995).

▼ Users scheduled to be provided with groundwater during Phase 2 and then recycled water after completion of Phase 3 of the Recycled Water Master Plan (1995).

■ Other potential non-potable water users.

SOURCE: City and County of San Francisco, 1992 and 1995

Figure 2-6
Location of Potential Non-Potable Water Users

The City's Current Water Supply System

The San Francisco Hetch Hetchy Water and Power Department transports surface water from the Tuolumne River watershed (Hetch, Hetchy, Lake Lloyd, and Lake Eleanor Reservoirs) in the Sierra Nevada across the San Joaquin Valley into Alameda County. The transmission pipelines for this surface water supply are designed to have the capacity to deliver 300 mgd of water. For planning purposes, however, the Hetch Hetchy Water and Power Department estimates that the firm delivery yield is 240 mgd, based on estimates of the maximum amount of water the system could produce under worst-case dry periods (City and County of San Francisco, 1994a). From Alameda County, the surface water supply is split, and the Water Department transmits some of the water south into and through Santa Clara County, and the remainder west into and through San Mateo County, eventually into San Francisco County (Figure 2-7).

Using this surface water supply, the Water Department serves 33 wholesale customers in Alameda, Santa Clara, and San Mateo Counties, and retail customers in the City. This surface water supply is augmented by local surface water (Calaveras, San Antonio, Crystal Springs, San Andreas, and Pilarcitos Reservoirs), groundwater, and other surface water from sources such as the California Emergency Water Bank.

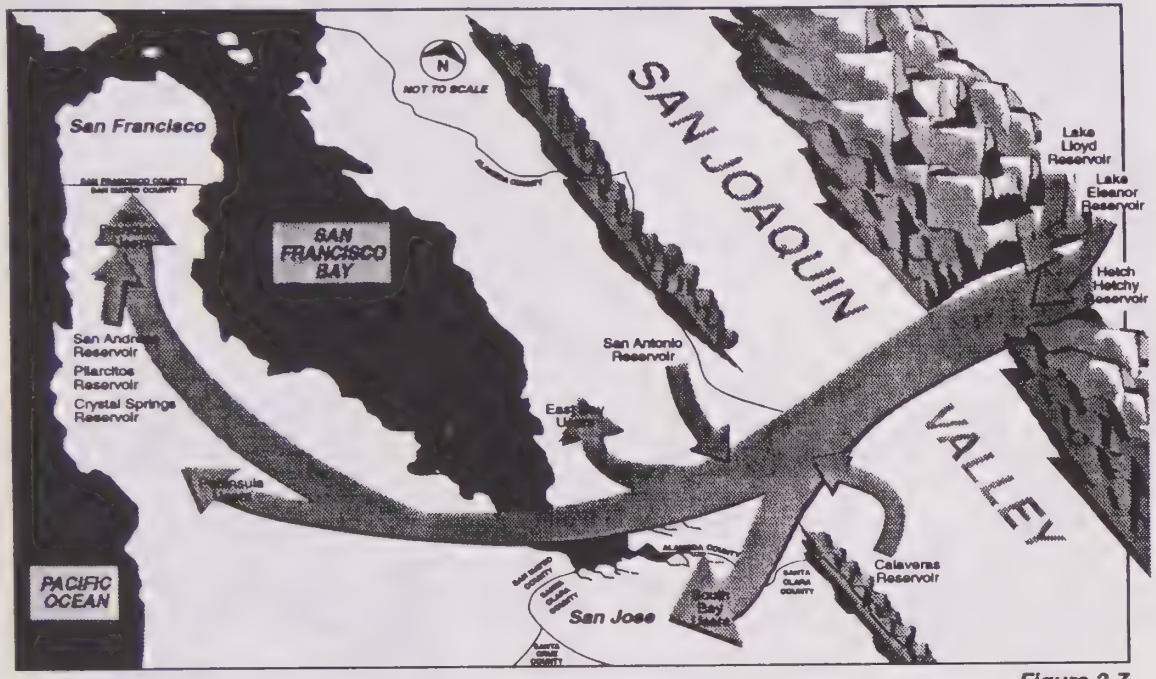


Figure 2-7
Schematic of the San Francisco Water Supply System

Groundwater Resources

Groundwater in the seven basins beneath the City (including three basins that extend beyond the City boundaries) is a valuable resource that is currently not managed. Based on assumptions of aquifer thickness and size, and on groundwater elevation data collected during the 1987-1992 drought (the only period with adequate groundwater elevation data), some groundwater basins can yield additional groundwater for use by City customers.

As noted in Table 2-2 and throughout this Master Plan, however, the Water Department must address several technical and institutional issues before producing additional groundwater to supply its customers. To understand how much groundwater could potentially be developed in both the short and the long term, the Water Department assessed available relevant data for each basin. Known information about the groundwater resources of each basin is summarized in Table 2-2 and discussed below.

Table 2-2
Summary of Groundwater Resources

Basin	Estimated Average Annual Recharge (ac-ft/yr)[a,b]	Likely Groundwater Quality[c]	Development Potential (reason)	Amount of Groundwater Extracted from Basin (1993)[d]	
				(ac-ft/yr)	(mgd)
Westside	14,800[e]	Potable	High (north of Lake Merced, conjunctive use potential)	~13,800	12.3[f]
Lobos	1,600	Potable	Medium (conjunctive use potential)	2,300[g]	2
Marina	1,300	Unknown	Low (high subsidence potential)	Unknown	--
Downtown	5,900	Nonpotable	Medium-Low (high water levels, high subsidence potential)	800 - 5,600[h]	0.7 - 5
Islais Valley	1,800	Unknown	Insufficient data	Unknown	--
South	700	Unknown	Insufficient data	Unknown	--
Visitacion Valley	Unknown	Unknown	Insufficient data	Unknown	--

[a]Recharge estimates are based on USGS data (Phillips et al., 1993), except for data from the portion of the Westside Basin south of the county line. USGS data were collected for 1987 and 1988, the first years of a 6-year drought. Recharge estimates have been rounded to the nearest 100 acre-feet.

[b]Recharge includes leakage from underground pipes, which has not been specifically quantified. It can be assumed that recharge from this source will decrease in the future as repairs to the system are made.

[c]Potential sources of groundwater contamination exist in each basin (see Figure 3-5, Section 3). Where groundwater quality conditions are known, a preliminary assessment of the potable or nonpotable water quality is shown.

[d]Numbers are estimates based on City and Bay Area Water Users Association records. Estimates may be low because pumping records are incomplete (no requirement for reporting exists).

[e]Includes recharge of both the northern and southern portions of the Westside Basin. Applied Consultants (1991) estimated the average annual recharge to the southern portion of the Westside Basin to be 9,970 ac-ft/yr. Phillips et al. (1993) estimated the average annual recharge to the northern portion of the Westside Basin to be 4,900 ac-ft/yr.

[f]Extraction based on Bay Area Water Users Association estimate of 7.3 mgd municipal use and 3 mgd non-municipal use and Water Department estimate of 2 mgd use.

[g]Lobos Creek flow (1,800 ac-ft/yr) plus documented groundwater extraction (530 ac-ft/yr). Additional evaluation is necessary to determine whether the recharge and extraction numbers accurately represent Lobos Basin conditions.

[h]Groundwater extracted in the Downtown Basin is assumed to be for dewatering. 800 ac-ft/yr are known to be extracted, but the San Francisco Department of Public Works estimates that an average of 5,600 ac-ft/yr of dewatering water is added to the sewer system.

Estimated Average Annual Recharge

Table 2-2 lists estimates of the annual average amount of recharge for each basin, i.e., the amount of water entering the basin each year from percolation to the water table of irrigation water or rainfall, or from leakage of underground pipes. As the table indicates, the Westside and Downtown Basins have the highest annual average recharge rate. The recharge values were calculated by the USGS based on data collected during 1987 and 1988, both drought years in northern California.

Development Potential

Table 2-2 also presents the Water Department's qualitative judgment of the groundwater development potential of each basin based on aquifer thickness, susceptibility to subsidence and saltwater intrusion, and historic groundwater levels. A thick aquifer, such as that found in portions of the Westside Basin, increases the development potential of the basin because of the large volume of groundwater contained within it and the ability to extract groundwater from different intervals within the aquifer. Conversely, subsurface sediments with a high clay content, such as those found in the Downtown and Marina Basins, make an area susceptible to subsidence, and groundwater development requires a high level of planning and coordination.

Likely Groundwater Quality

The Water Department's qualitative assessment of overall groundwater quality in each basin is included in Table 2-2. This assessment, based on the historic and recent analytical results of groundwater samples collected from a number of locations within the basin, is a generalization of basinwide groundwater quality. Further analysis will be necessary at each new well site to determine local water quality.

Groundwater in the southern portion of the Westside Basin and Lobos Basin already is used for potable purposes and is routinely sampled and analyzed for compliance with drinking water standards. The groundwater of these basins is, therefore, considered potable.

Groundwater in the northern portion of the Westside Basin is also considered potable based on limited historic data and preliminary sampling results obtained during the winter of 1993 from 10 locations in the basin. These data and available historical data indicate that occasional concentrations of nitrates, chlorides, iron, total dissolved solids, and fecal coliform have been detected above drinking water standards. However, these measurements occur at scattered locations and vary through the period of the record. Collection of additional site-specific water quality data will be necessary before the proposed projects are implemented. Ongoing monitoring will also be necessary for future protection of groundwater quality.

Downtown Basin groundwater is being considered for nonpotable uses only (i.e., toilet flushing, irrigation, and climate control) because of the historic industrial development and the density of identified hazardous waste sites. Analysis of 20 water samples in 1993 from the Downtown Basin showed that 19 of the 20 wells contained water suitable for selected nonpotable municipal and industrial development uses without treatment. Only five of these samples met Title 22 Drinking Water Standards for bacteriological, general physical, general mineral, and inorganic chemical analyses.

Insufficient data are available for an assessment of groundwater quality in the Marina, Islais Valley, South, and Visitacion Valley Basins.

Amount of Groundwater Extracted from Basin

Table 2-2 also presents the Water Department's estimate of the approximate total amount of groundwater extracted from each basin during 1993. The difference between the estimated average annual recharge and the extracted amount yields a preliminary estimate of the maximum additional amount of groundwater that could be withdrawn from the basin during an average year without increasing recharge. Because withdrawing the maximum amount of groundwater could potentially induce undesirable effects (such as saltwater intrusion or subsidence), the Water Department recognizes that full withdrawal of this amount will not occur.

Evaluation of Groundwater Resources and Water Demand

The Westside and Downtown Basins have the largest basin capacity, the highest estimated average annual recharge, and the highest demands; therefore, they have the greatest potential for groundwater development. By contrast, the Marina Basin's aquifer is thin, with a high potential for subsidence, and the quality of its groundwater is unknown. For these reasons, the Marina Basin has a much smaller potential for development and, pending additional studies, may be considered for minimal future groundwater development only.

In the South, Visitacion, and Islais Valley Basins, groundwater is generally undeveloped, and information on hydrogeologic properties and water quality is limited. Evaluation of the development potential of groundwater in these basins would require additional data collection and user surveys. Although these basins are not likely candidates for development in the near term, the Water Department will assess the potential for long-term development after the additional studies have been completed.

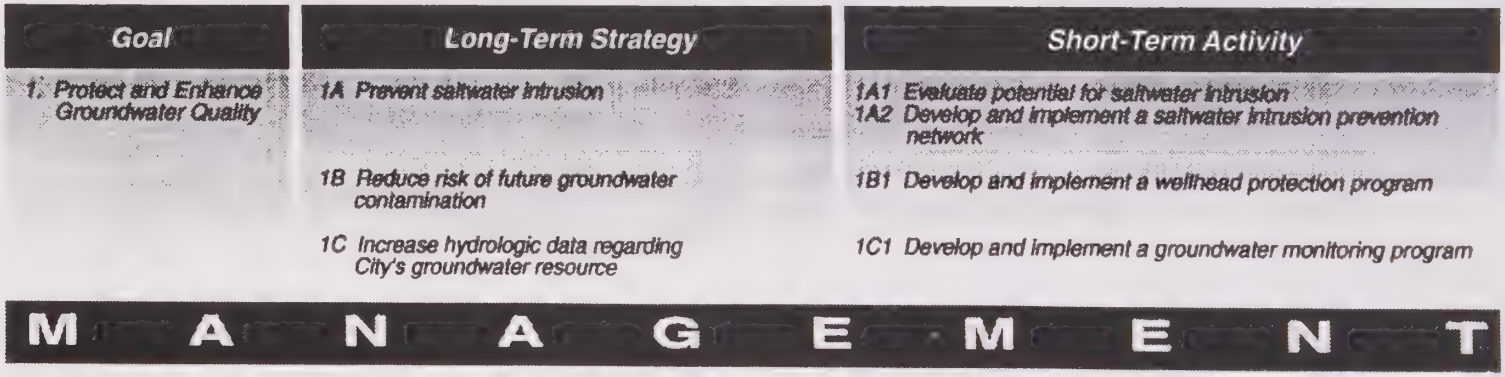
Finally, groundwater in the Lobos Basin was developed for use by the U.S. Army at the Presidio Army Base. The Presidio was transferred to the National Park Service (NPS) in September 1994. The SFWD wants to protect this shared basin for future water production and conjunctive use opportunities. To meet this objective, the Water Department has initiated discussions with the NPS to establish baseline data for the basin and to institute basin protection measures.

Section Three - Goal 1: Protect and Enhance Groundwater Quality

The Water Department has identified the protection and enhancement of groundwater quality as a critical goal in order to protect groundwater as a potential long-term water supply. If groundwater quality deteriorates, wellhead treatment or additional distribution facilities will be needed. Such facilities can be expensive and would increase the cost of groundwater. Groundwater quality can be degraded in many ways (such as through the intrusion of salt water into a freshwater aquifer or leakage from underground storage tanks or buried sewers). Degradation of water quality would reduce the basin yield, thereby diminishing production from existing activities and limiting future groundwater development activities.

Three long-term strategies designed to protect and enhance groundwater quality are shown in Figure 3-1. These long-term strategies and the short-term activities associated with them are discussed below.

Figure 3-1
Goal 1



Strategy 1A: Prevent Saltwater Intrusion

Generalized groundwater flow in an undeveloped coastal area is shown in Figure 3-2a; fresh water from the coastal aquifer occurs above the more dense salt water. The salt water is prevented from migrating landward by the hydraulic head of the fresh water, which must be high enough above sea level to offset the greater density of the salt water. Once over-pumping of the aquifer begins at rates high enough to reduce the freshwater hydraulic head or at rates greater than the natural flow through the aquifer, the denser salt water begins to migrate towards the well, as shown in Figure 3-2b. Eventually, with continued over-pumping of groundwater, the salt water moves far enough inland to be extracted from the well (Figure 3-2c). When salt water is pumped from a well, the local groundwater may no longer meet acceptable water quality standards, and the value of that groundwater basin decreases. The Water Department has defined two activities to prevent this potential degradation of water quality.

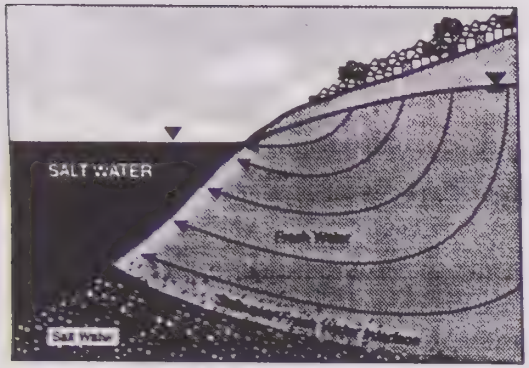


Figure 3-2a
Groundwater Flow in an Undeveloped Coastal Basin

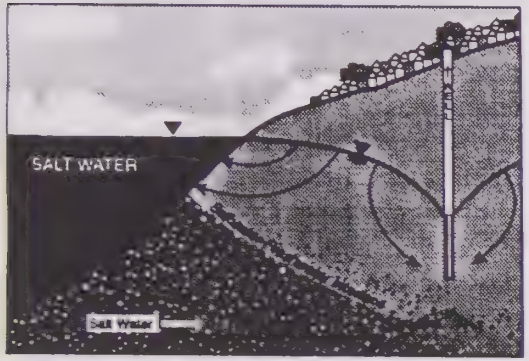


Figure 3-2b
Onset of Saltwater Intrusion Resulting from Over-Pumping in a Coastal Basin

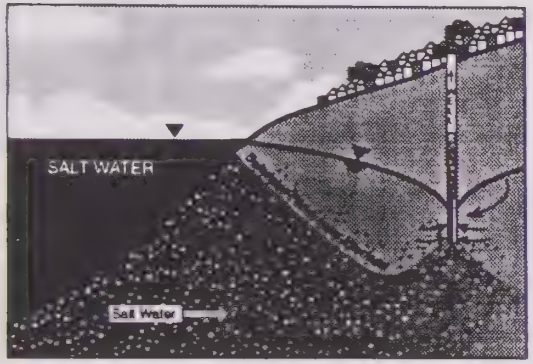


Figure 3-2c
Saltwater Intrusion Resulting from Over-Pumping in a Coastal Basin

Activity 1A1: Evaluate Potential for Saltwater Intrusion

The potential for inducing saltwater intrusion into a potable aquifer is a primary concern when developing groundwater in a coastal area such as San Francisco. To avoid creating the situation shown in Figure 3-2c when implementing its goal of increasing groundwater use (Goal 5), the Water Department has developed a groundwater model using existing available hydrogeologic data.

The Saltwater Intrusion Model is an analytical tool developed to assist the City in evaluating the effects of pumping rate and location on the saltwater-freshwater interface in the portion of the Westside Basin north of Lake Merced (Figure 3-3). This area is considered to have the highest potential for potable groundwater development within the City and County of San Francisco.

The Saltwater Intrusion Model has been used to provide preliminary estimates for evaluating the proposed groundwater development options being considered in the Sunset District: Activities 5A1 (Extract groundwater from Elk Glen Well) and 5A2 (Extract groundwater from the Sunset District), which are discussed in Section 7. The model has been used to evaluate the effects of moving the proposed well locations and varying the quantity of water proposed to be extracted on the saltwater-freshwater interface. It has also been used to identify the area contributing water to the wells under different conditions to assess how much recharge the wells will capture and whether the proposed extraction affects groundwater conditions in the vicinity of Lake Merced.

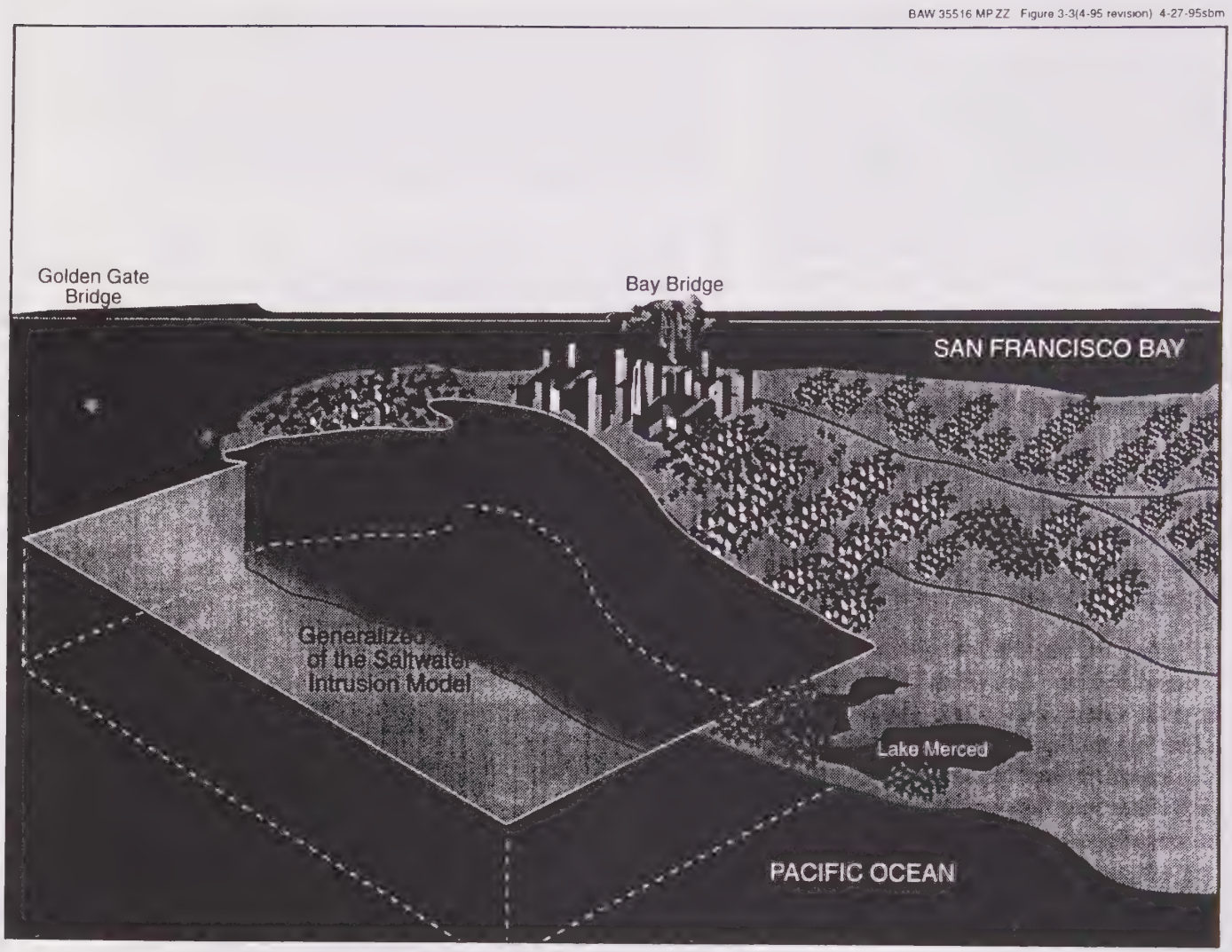


Figure 3-3
Generalized Area of the Saltwater Intrusion Model

The model will be used by the City during planning and development of the proposed locations to assess how changes in existing groundwater use or recharge conditions affect the potential for additional groundwater development in the area. Additionally, the City will collect water quality and water level data during testing and development of the area to determine whether the model is accurately reproducing groundwater conditions. Model improvements will be made as additional hydrogeologic data are collected.

Activity 1A2: Develop and Implement a Saltwater Intrusion Prevention Network

As the City's near-shore groundwater development begins, the Water Department plans to develop a saltwater intrusion prevention network. In addition, a groundwater monitoring and contingency plan to prevent saltwater intrusion during operation of the planned wells will be developed.

Concurrent with, or prior to, installation of the proposed production wells identified in Activities 5A1 (Extract groundwater from Elk Glen Well) and 5A2 (Extract groundwater from the Sunset District) (see Section 7), the City will identify monitoring well locations between the estimated present saltwater interface and the proposed production wells. The possibility of using existing wells will be considered as an alternative to the installation of new wells. Before and after operation of the new production wells begins, water levels and water quality indicators (i.e., total dissolved solids and chloride) will be monitored routinely within the monitoring wells. These data will be collected and evaluated to manage groundwater pumping within the basin relative to preventing saltwater intrusion.

If the saltwater interface is moving landward as a result of the pumping at the new production wells (Figure 3-4a), one of two actions can be taken. Either pumping at the production wells can be reduced to levels that will not induce saltwater intrusion, or recharge water can be introduced into the aquifer via injection wells (Figure 3-4b).

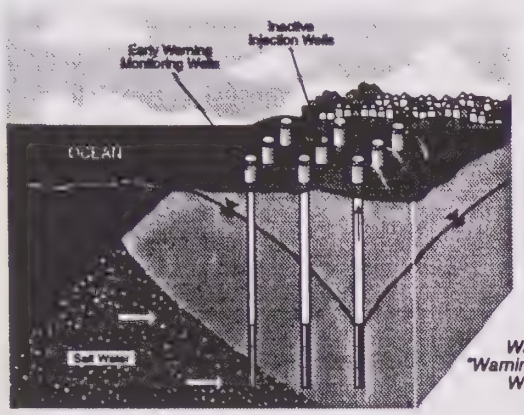


Figure 3-4a
Water Quality Data from "Warning System" Monitoring Wells Indicate Saltwater Intrusion is Beginning

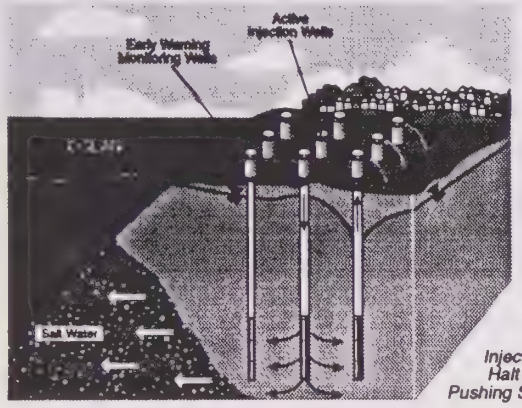


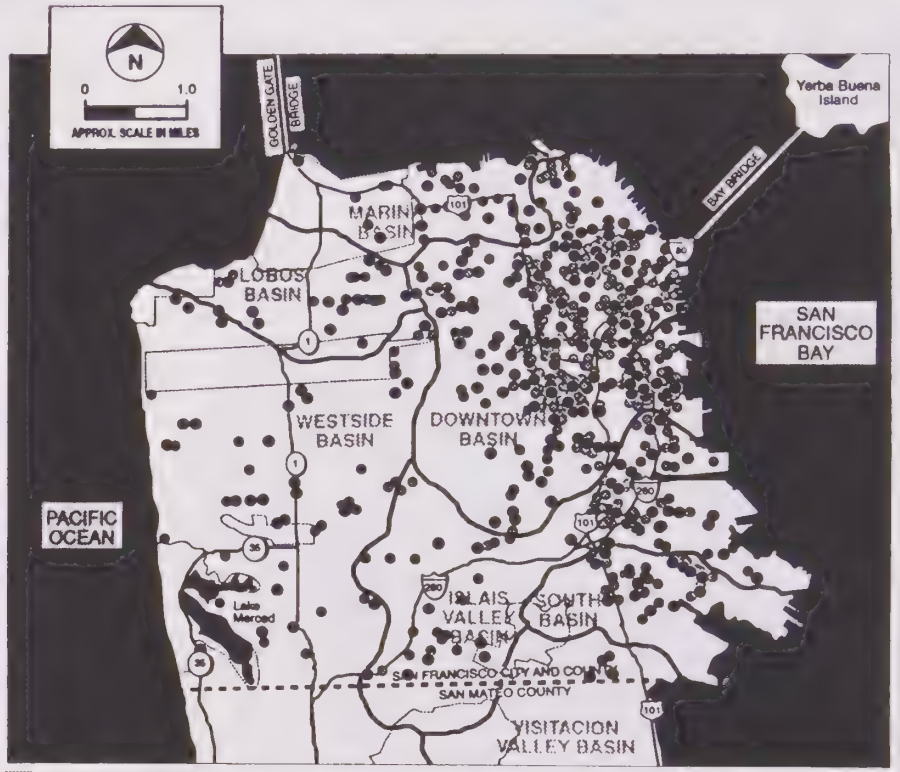
Figure 3-4b
Injection Wells Activated to Halt Saltwater Intrusion by Pushing Salt Water Oceanward

The groundwater monitoring and contingency plan will address the following issues:

- Monitoring well locations, as necessary
- Injection well locations, as necessary
- Injection water sources (consider recycled water, surface water, and groundwater, depending on the revised regulations for groundwater recharge currently being developed by the state)
- Sampling parameters, procedures, and frequency/ schedule
- Action levels for implementation of the contingency plan (i.e., conducting one of the two actions to counter saltwater intrusion)
- Specific actions to be taken to counter saltwater intrusion

Strategy 1B: Reduce Risk of Future Groundwater Contamination

Lists of sites where hazardous or petroleum materials have been found in the soil or groundwater (usually at industrial sites) are maintained by the California Regional Water Quality Control Board, San Francisco Bay Region; the California Environmental Protection Agency, Department of Toxic Substances Control, Region 2; and the Department of Health Services of the Counties of San Francisco and San Mateo. The distribution of these sites within the City (as of 1995) is shown in Figure 3-5. Although contamination has not been identified in the groundwater at each of the mapped sites, sites with known soil contamination represent a potential threat to present or future groundwater quality.



SOURCE: Regional Water Quality Control Board, 1994.

Figure 3-5
Known Sites Where Hazardous or Petroleum Materials Have Been Released to the Environment

To prevent degradation of groundwater beneath areas intended or already under development for groundwater use, existing groundwater contamination in these areas should be managed to reduce the risk of future groundwater contamination. Types of groundwater contamination to be considered include those from both point sources (contamination originating from specific locations) and nonpoint sources (contamination originating from multiple or diffuse locations, such as pesticide and herbicide use in landscape areas and gardens). Nonpoint sources within the City have not yet been identified by any state, federal, or City agency.

One short-term activity has been identified to achieve the long-term strategy of reducing the risk of groundwater contamination.

Activity 1B1: Develop and Implement a Wellhead Protection Program

The objective of a wellhead protection program is to locate potential sources of groundwater contamination within a specified protection area and to reduce the risk of these potential sources affecting groundwater quality.

One component of a wellhead protection program is an approach to well permitting (Figure 3-6) designed to minimize potential groundwater contamination. The permit requirements should be revised to include a complete plan describing well construction details, a delineation of wellhead protection areas (Figure 3-7), an analysis of the proximity of the proposed new well to potential contamination sources (Figure 3-8), an analysis of potential contaminant travel time, a proposed groundwater quality sampling program, and an analysis of potential effects of the proposed new well on saltwater intrusion and other environmental considerations.

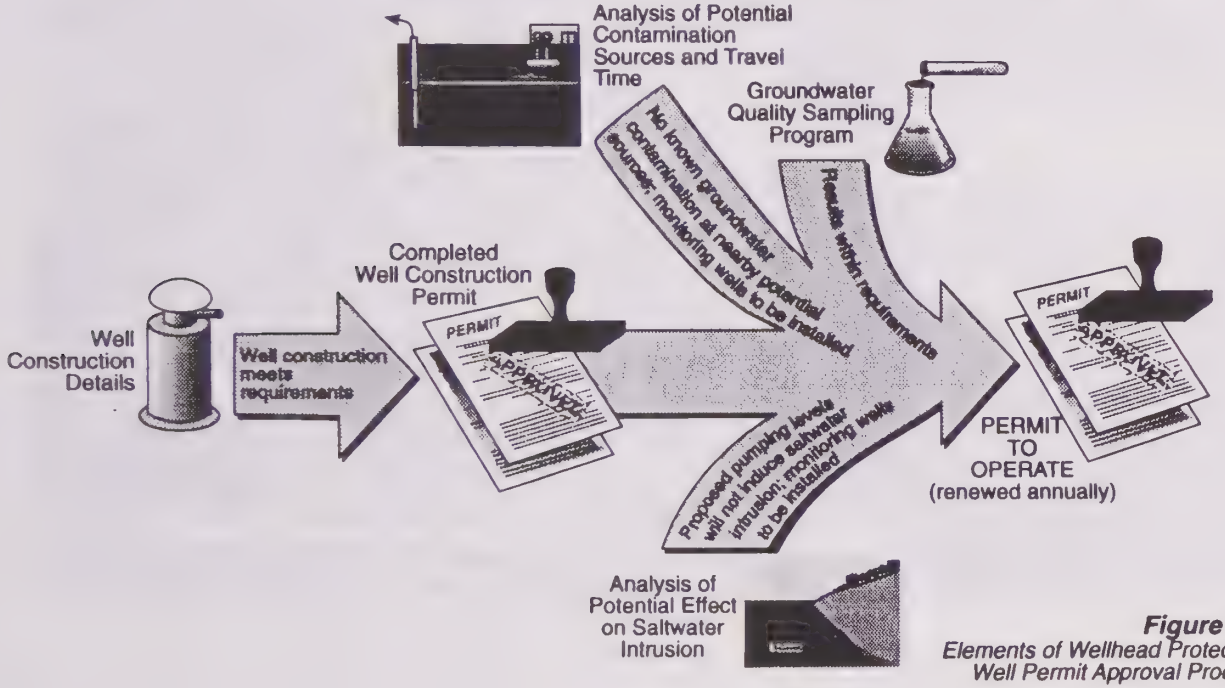


Figure 3-6
Elements of Wellhead Protection Well Permit Approval Process

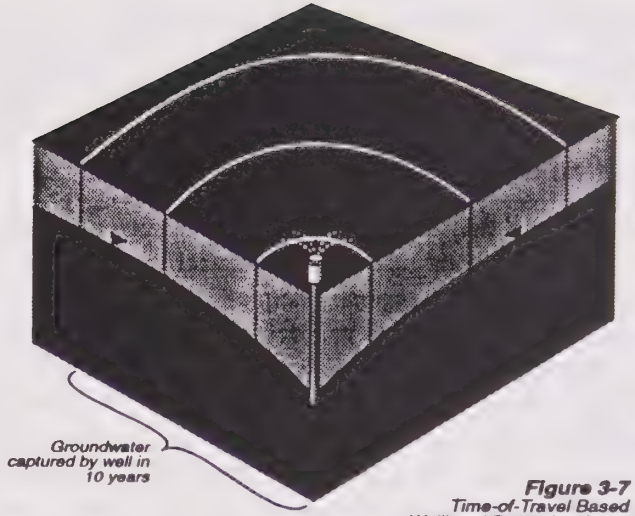


Figure 3-7
Time-of-Travel Based Wellhead Protection Areas

The San Francisco Department of Public Health currently administers the City's well permitting program. Permits are required for construction, operation, and abandonment of all wells in the City and for drilling soil borings. Section 4 describes the way the proposed Groundwater Management Unit of the Water Department will work with the San Francisco Department of Public Health to use the existing well permitting system in managing the City's groundwater basins as a long-term resource. Under a program focused on protecting water quality, well permit applications that pose a risk to the long-term resource will be denied.

The Water Department's wellhead protection program would include the following components:

- Delineate "wellhead protection areas"
- Develop a management program to protect the water supply from contaminants within a "wellhead protection area"
- Identify potential contamination sources, including known industrial contamination sites, present and historic sites where activities potentially affecting water quality may have occurred, and nonpoint sources

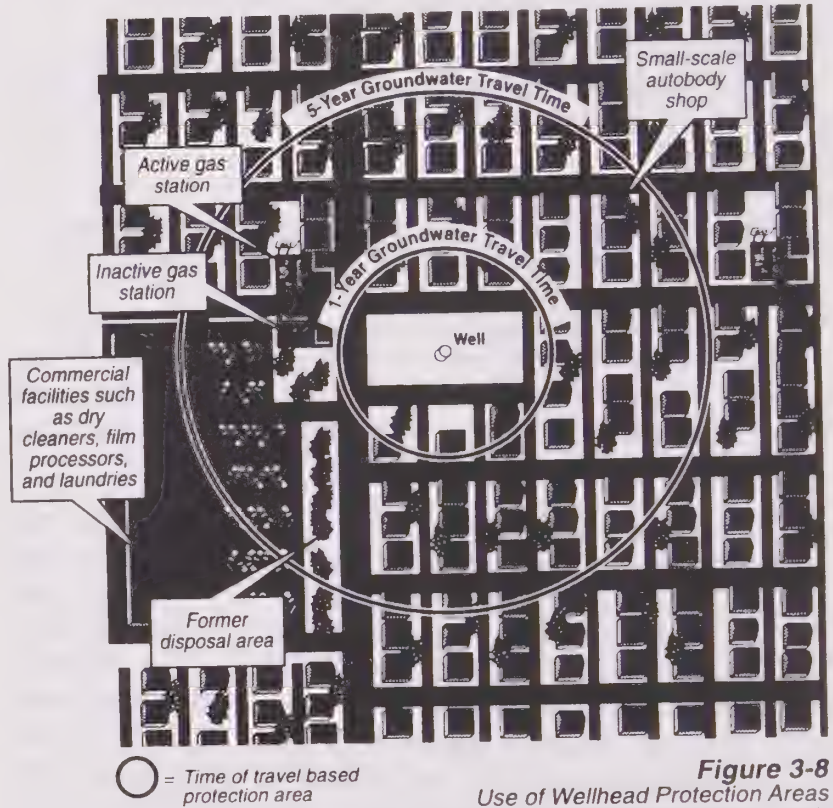


Figure 3-8
Use of Wellhead Protection Areas to Identify Management Tools (Potential pollution source inventory is shown)

- Install well meters and require reporting of water use
- Develop contingency plans to respond to emergencies within the wellhead protection areas
- Facilitate public participation in the development and implementation of wellhead protection management practices
- Specify the roles and duties of agencies for each of the activities of the wellhead protection program
- Work with the California Regional Water Quality Control Board on basin designations and identifying high-priority aquifers for groundwater development and high priority site cleanups
- Develop strategies the City can implement to reduce the threat of contamination from City facilities
- Develop a program to implement enforcement actions against entities responsible for contamination (this component of the program may require review and revision of the City's ordinances concerning groundwater)

The City does not currently have a wellhead protection program in place. In fact, the Water Department is not the sole City department responsible for managing and protecting groundwater. Three other entities also have responsibilities. The San Francisco Department of Public Health is responsible for well permits and the investigation and remediation of industrial pollution sites. The San Francisco Department of Public Works Site Assessment and Remediation group assists in writing specifications for construction projects to prevent groundwater contamination and works with the Department of Public Health in investigation and remediating contaminated sites. The California Regional Water Quality Control Board is responsible for implementing Resolution 68-16, the state's groundwater anti-degradation policy.

Over the past 50 years, while most of the groundwater in the City has been used for nonpotable purposes, the permitting system has been adequate. However, with the Water Department's current goal of developing and using groundwater for both potable and nonpotable uses, and with the increasing understanding of potential threats to groundwater quality, the Water Department will work with the appropriate departments and agencies to develop a comprehensive wellhead protection program based on the components described above. Implementation of such a program will require revision of the duties and roles of the involved agencies.

Strategy 1C: Increase Hydrologic Data Regarding City's Groundwater Resource

Reliable groundwater data are the key to successful management of a groundwater basin. Long-term monitoring and analysis of groundwater levels, groundwater extractions, and groundwater quality allow more rapid identification of, and response to, changes attributable to manageable external influences (e.g., overdrafting or a leaking underground tank). Collecting and maintaining groundwater data in a usable format is necessary for managing the City's groundwater as a long-term resource.

Activity 1C1: Develop and Implement a Groundwater Monitoring Program

The Water Department plans to develop a monitoring program to collect data on groundwater levels, extractions, and water quality to produce its groundwater database for the City's seven groundwater basins. For those basins underlying adjacent jurisdictions, the Water Department will work closely with the applicable jurisdictions to collect and analyze appropriate data for the common benefit. Such a program would include both private and public dewatering, irrigation, extraction, monitoring, and supply wells. The monitoring program may also include measurement of water levels in Lake Merced, Lobos Creek, and any other surface water bodies that interact with local groundwater.

Data collected during the monitoring program will be entered in the GIS database developed as part of this Master Plan. The proposed Groundwater Management Unit of the Water Department (described in Section 4) will be responsible for conducting the annual monitoring program, updating the GIS database, and interpreting data to identify locations of possible declines in groundwater quality or quantity. These data may also be used to develop and update groundwater models of the City's basins.

Section Four - Goal 2: Coordinate Groundwater Use

To develop and manage the City's groundwater efficiently, the Water Department must coordinate with its users, other City agencies, and neighboring political entities. Four long-term strategies have been identified to meet the goal of coordinated groundwater use (Figure 4-1). The short-term activities the Water Department may undertake to implement each of the strategies are described below.

Strategy 2A: Establish Water Department as Lead in City Groundwater Management

The Water Department recognizes that implementing the long-term strategies and the short-term activities described in this Master Plan will require continued planning, development, and monitoring, and that committed City resources are essential for such an undertaking to succeed.

Activity 2A1: Establish a Groundwater Management Unit Within the Water Department

The Water Department will form an internal Groundwater Management Unit. The new unit will be established as a resource for technical information about City groundwater and will act as a clearinghouse for distributing information to the public. Formation of this unit as early as possible during the implementation of the Master Plan will support its successful implementation.

Figure 4-1
Goal 2

Goal	Long-Term Strategy	Short-Term Activity
2. Coordinate Groundwater Use	2A Establish Water Department as lead in City groundwater management	2A1 Establish a Groundwater Management Unit within the Water Department
	2B Improve coordination with other government agencies regulating/affecting groundwater use within the City	2B1 Form a City groundwater management committee
	2C Improve coordination with adjacent entities whose groundwater use affects shared groundwater basins	2C1 Form appropriate AB 3030 management committee(s)
	2D Enhance communication with Water Department customers	2D1 Develop and implement a public information program

M A N A G E M E N T

The Groundwater Management Unit will likely consist of one supervisor-level hydrogeologist or hydrologist and two staff-level hydrogeologists or hydrologists. The supervising hydrogeologist or hydrologist should be a California-registered geologist or professional engineer.

The Groundwater Management Unit will be responsible for the following tasks:

- Implement Master Plan activities
- Develop new activities and strategies to help the City meet the goals outlined in the Master Plan
- Maintain, update, and use the GIS database and groundwater models
- Work with other City departments and adjacent political entities on activities involving City groundwater
- Respond to public inquiries about City groundwater
- Implement groundwater monitoring programs (collect data on groundwater level, use, and quality)
- Update the groundwater contribution to the overall City water balance
- Monitor groundwater quality in the City
- Implement relevant permitting programs (e.g., issuing well permits subject to California Environmental Quality Act [CEQA] review by the Water Department, City Planning, and the Department of Health) in conjunction with other City departments
- Monitor local, state, and federal legislation relevant to the use, protection, or management of groundwater
- Support the Water Department in efforts to foster new legislation for groundwater protection and use issues, both at City and state levels

Creation of the Groundwater Management Unit will be the first step toward establishing the Water Department as the lead agency in charge of managing the City's groundwater resources. Currently, Section 3.591 of the City's Charter defines the Public Utilities Commission as having authority over all utility properties and groundwater. However, outstanding issues will require attention through interagency agreements and the possible use of state groundwater management statutes.

Groundwater Underlying City-Owned Properties. Establishing the Water Department as lead agency to manage the City's groundwater resources requires agreement with other City departments about the surface uses of land within these departments' jurisdiction. This could be accomplished through a Memorandum of Understanding (MOU) for the construction of facilities needed to manage groundwater beneath City-owned properties.

Groundwater Underlying Private Property. Groundwater underlying private property usually belongs, by law, to the overlying property owner who shares extraction rights in a correlative fashion with other overlying landowners. However, the City holds rights to all groundwater in San Francisco based on its historic Pueblo water right to all water within the boundaries of the historic Pueblo of San Francisco. Additionally, the Groundwater Management Unit of the Water Department could represent the City and work in partnership with agencies outside the City limits by forming a water or replenishment district or by developing an AB 3030 Groundwater Management Plan. A water or replenishment district is formed through state legislation; an AB 3030 management district is formed by passing a resolution to develop an AB 3030 plan, developing the management plan, and allowing the public to approve the plan following a public review. Requirements for the AB 3030 process are outlined in the California Water Code (10750 et seq) and discussed on page 4-4 of this Master Plan.

Strategy 2B: Improve Coordination with Other Government Agencies Regulating/Affecting Groundwater Use Within the City

This strategy facilitates cooperation among agencies so that policies of one agency do not conflict or interfere with the policies of other agencies. Currently, the activities of several City departments, and a number of state and federal agencies, affect the disposition of City groundwater. These departments are as follows:

- The City Department of Public Works, which, along with the Water Department, is responsible for developing the City's recycled water program and whose cooperation is necessary to identify potential alternative water source users and whether recycled water or groundwater can supply their water needs
- The City Recreation and Park Department, which is the largest groundwater user in the City, mainly at Golden Gate Park (a high percentage of this water is recharged back to the aquifer)
- The City Planning Department, which approves developments that may affect groundwater quality
- The California Department of Health Services and the City's Department of Public Health, which enforce potable water quality regulations
- The California Regional Water Quality Control Board, the City Department of Public Health, and the Department of Public Works Bureau of Environmental Regulation and Management, which regulate clean up of groundwater contamination and mandate groundwater quality monitoring at its point source
- The U.S. Environmental Protection Agency, which regulates clean up of soil and groundwater contamination at sites included on the National Priorities List (Superfund sites)

- The City Fire Department (responsible for the Auxiliary Water Supply System [AWSS]), which provides emergency supplies to large parts of the City and whose existing distribution system may receive groundwater from dewatering operations
- The National Park Service, which manages groundwater use at the Presidio in the Lobos Basin

Activity 2B1: Form a City Groundwater Management Committee

As a first step in improving coordination among agencies, the Water Department will take the lead by establishing a committee of representatives from the agencies listed above who will have some involvement in groundwater production, use, and distribution. This committee will:

- Determine guidelines for communication, permitting, and interjurisdictional coordination of activities (including active well monitoring)
- Coordinate development of subcommittees to address groundwater conditions in City basins (such as AB 3030 plans)
- Develop a management plan outlining the responsibilities and authorities of each member agency

Strategy 2C: Improve Coordination with Adjacent Entities Whose Groundwater Use Affects Shared Groundwater Basins

The City shares portions of the Westside, Islais Valley, and Visitacion Valley Basins with political entities south of the City boundary (Figure 4-2). Effective basin management must include coordinated groundwater pumping and storage with other users to maintain the basins as long-term groundwater resources. Recent California legislation, AB 3030, facilitates joint management of a groundwater basin by multiple entities.

Activity 2C1: Form Appropriate AB 3030 Management Committee(s)

AB 3030 was passed by the California State Legislature in 1992 to encourage local public water agencies and other such entities to jointly develop and manage groundwater basins. This bill provides guidelines for developing interjurisdictional agreements and suggests activities that could be included in groundwater management plans. These include, but are not limited to, activities that protect water quality and quantity (Figure 4-3).

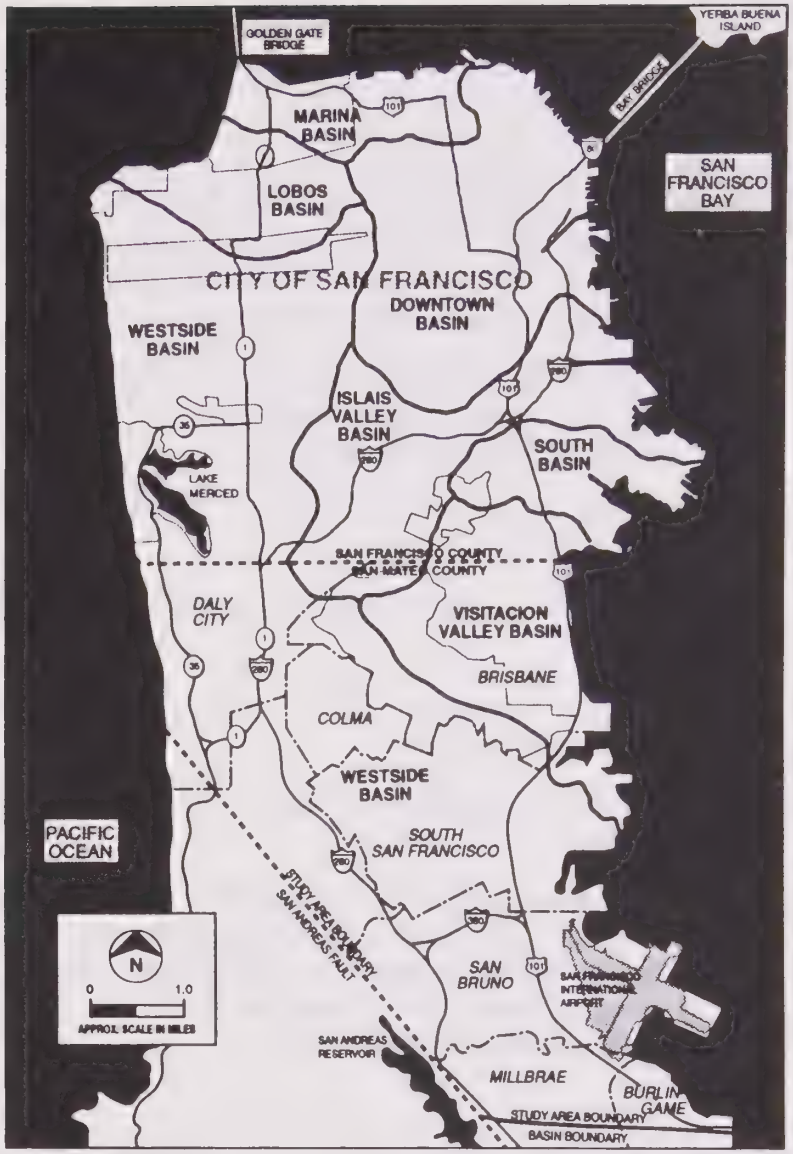


Figure 4-2
Groundwater Basins and the Overlying Political Entities

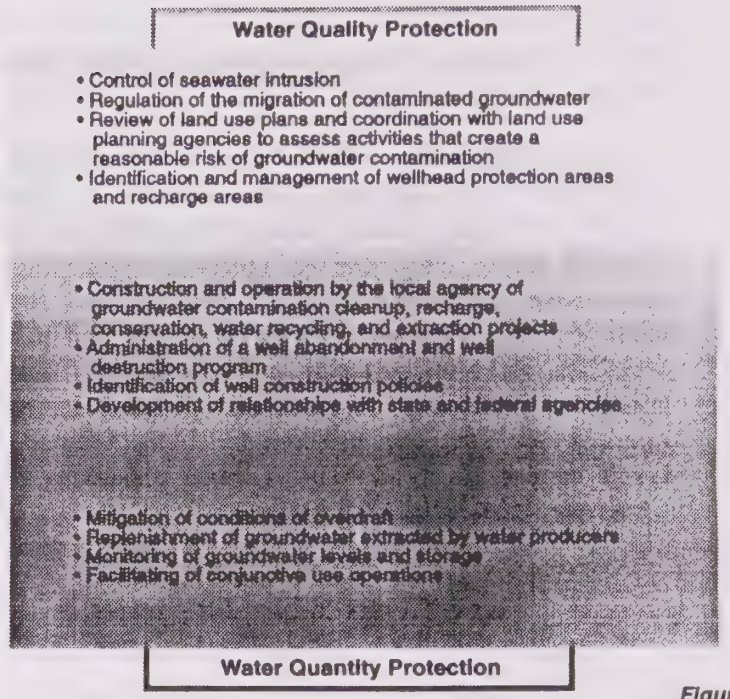


Figure 4-3
Groundwater Management Under AB 3030

Through this Master Plan, the Water Department has begun several activities that may become components of an AB 3030 plan for various basins. The Water Department may continue all or some of these activities for one or more of the seven groundwater basins discussed in this document. For two of the basins (South and Downtown Basins), only City departments and private landowners would be involved in forming an AB 3030 plan (or equivalent). In five of the basins (Lobos, Marina, Westside, Islais Valley, and Visitacion Valley Basins), City departments, private landowners, and other political

entities (such as Daly City or the National Park Service) and local utilities (California Water Service) would be involved.

The Water Department, the Cities of Daly City and San Bruno, and the California Water Service are working towards preparing a cooperative AB 3030 plan for the Westside Basin. This plan will facilitate development of a cooperative long-term solution to the problem of declining water levels at Lake Merced (see Activities 3A1 [Conduct additional field investigation at Lake Merced] and 3A2 [Conduct modeling to estimate effects of specific groundwater pumping patterns on Lake Merced water levels] in Section 5) and will facilitate addressing groundwater use issues within the basins.

Strategy 2D: Enhance Communication with Water Department Customers

The Water Department believes that a strong public involvement program will be important to foster customer understanding and support of the strategies and activities described in this Master Plan as well as the potential impacts of implementing the Master Plan. For example, the chemical constituents in groundwater vary from those of the existing surface water supply. This may result in a slight change in taste to San Francisco's water supply. Additionally, implementation of the program will have cost impacts.

Activity 2D1: Develop and Implement a Public Information Program

The Water Department and the Department of Public Works have prepared a joint information program for groundwater and recycled water. The purpose of such a program is to educate and communicate with the public regarding the work planned in the two master plans. The approach to the Public Information Program includes:

- Centralize the Water Department's interactions with the public to ensure consistency and credibility in communications and actions
- Define key messages to convey to Water Department customers
- Designate a Water Department member as spokesperson
- Identify customer groups that need special involvement efforts
- Establish a schedule and criteria for fact sheets and bulletins
- Distribute fact sheets and bulletins for anticipated events (e.g., field investigations, water quality monitoring, and well construction) and for unanticipated or not-yet-planned events (e.g., declining lake levels, future development activities)

- Distribute information to the public by way of the Water Department's newsletter inserted into water bills, articles written for the Recycled Water/ Groundwater Program newsletter, or the local media
- Establish procedures for working with the Department of Public Works to develop and update an informational slide show
- Coordinate with the Department of Public Works regarding appropriate public involvement milestones
- Hold a series of public meetings to present the results of the two master plans to the public and to address any public concerns that may arise

Section Five - Goal 3: Protect and Conserve Related Water Resources

The Water Department understands the need to consider the effects of groundwater development on surface water bodies and on local ecosystems that depend on water for survival. Of special concern are the potential environmental effects of changing water levels in surface water bodies within the Water Department's jurisdiction as a result of groundwater pumping. To address this concern, the Water Department has identified two long-term strategies for surface water features within its jurisdiction (Figure 5-1).

Figure 5-1
Goal 3

Goal	Long-Term Strategy	Short-Term Activity
3. Protect and Conserve Related Water Resources	3A Manage lake water levels	3A1 Conduct additional field investigation at Lake Merced 3A2 Conduct modeling to estimate effects of specific groundwater pumping patterns on Lake Merced water levels 3A3 Evaluate relationship between other City lakes and groundwater 3A4 Develop and implement policies and procedures to manage water levels in City lakes
	3B Manage stream water levels	3B1 Assess effects of groundwater development on Lobos Creek 3B2 Evaluate relationship between other City streams and groundwater 3B3 Develop and implement procedures to manage water levels in City streams

M A N A G E M E N T

Strategy 3A: Manage Lake Water Levels

Lakes within the City serve as emergency water supplies and wildlife habitats, and are used for recreation. Changing lake water levels affect these uses. The Water Department is committed to maintaining City lakes at levels that meet the balanced requirements of the potential uses. Figure 5-2 shows the locations of the major lakes within the City

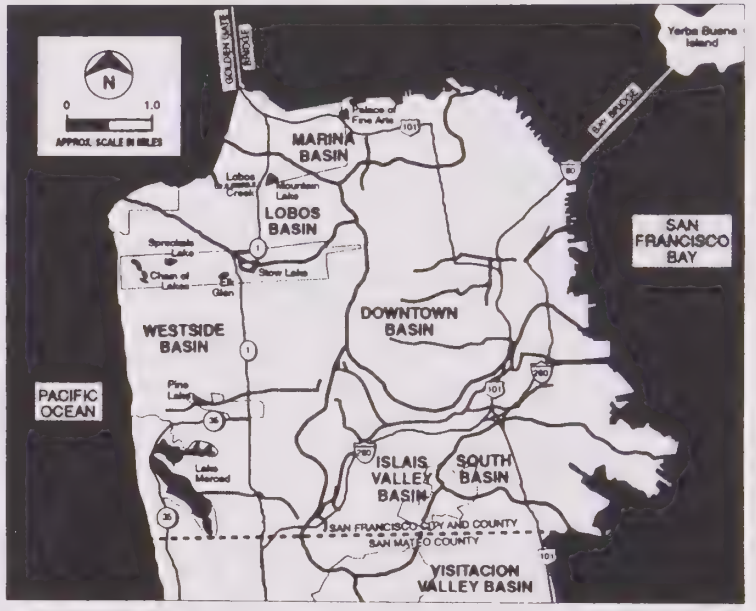
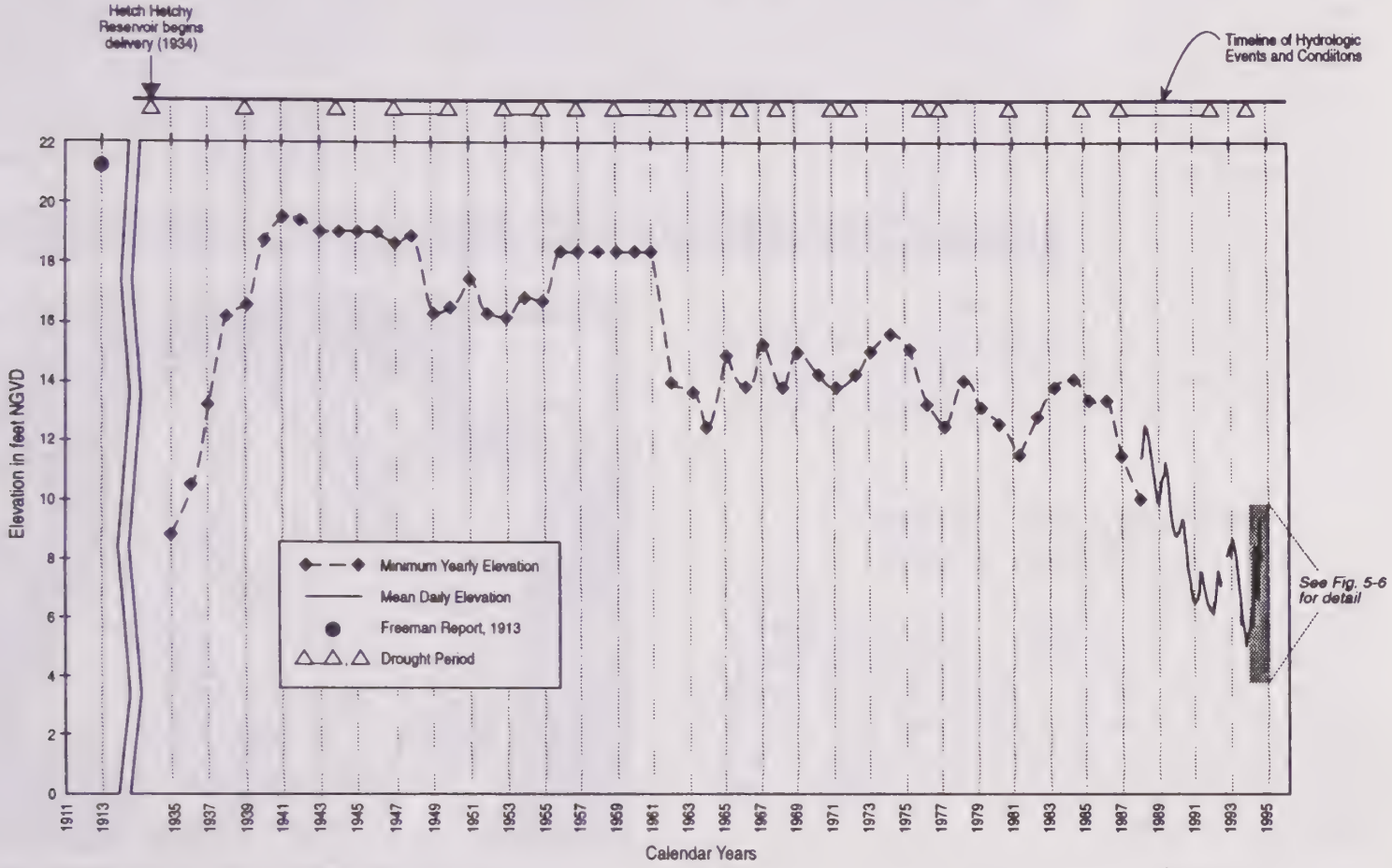


Figure 5-2
Location of Major Free-Flowing and Historic Creeks and Lakes

Reference for historic creeks: Clement, 1853

Activity 3A1: Conduct Additional Field Investigation at Lake Merced

Water levels in Lake Merced, the largest lake in the City, have been declining steadily over the past several years (Figure 5-3). The City's study of the Lake Merced area (Geo/Resource, 1993) included development of a groundwater flow model of the area (the Lake Merced Model, shown in Figure 5-4) and provided recommendations for optimum lake levels for wildlife, water quality issues, and developing lake management strategies. The 1993 recommendations for maintaining the optimum water level in Lake Merced were as follows:



NOTE: Drought period contains years classified as below normal, dry, or critically dry according to the Department of Water Resources

SOURCE: USGS. Mean daily records from Recorder 11162680 Lake Merced at Pumphouse

Figure 5-3
Changes in the Surface Elevation of Lake Merced

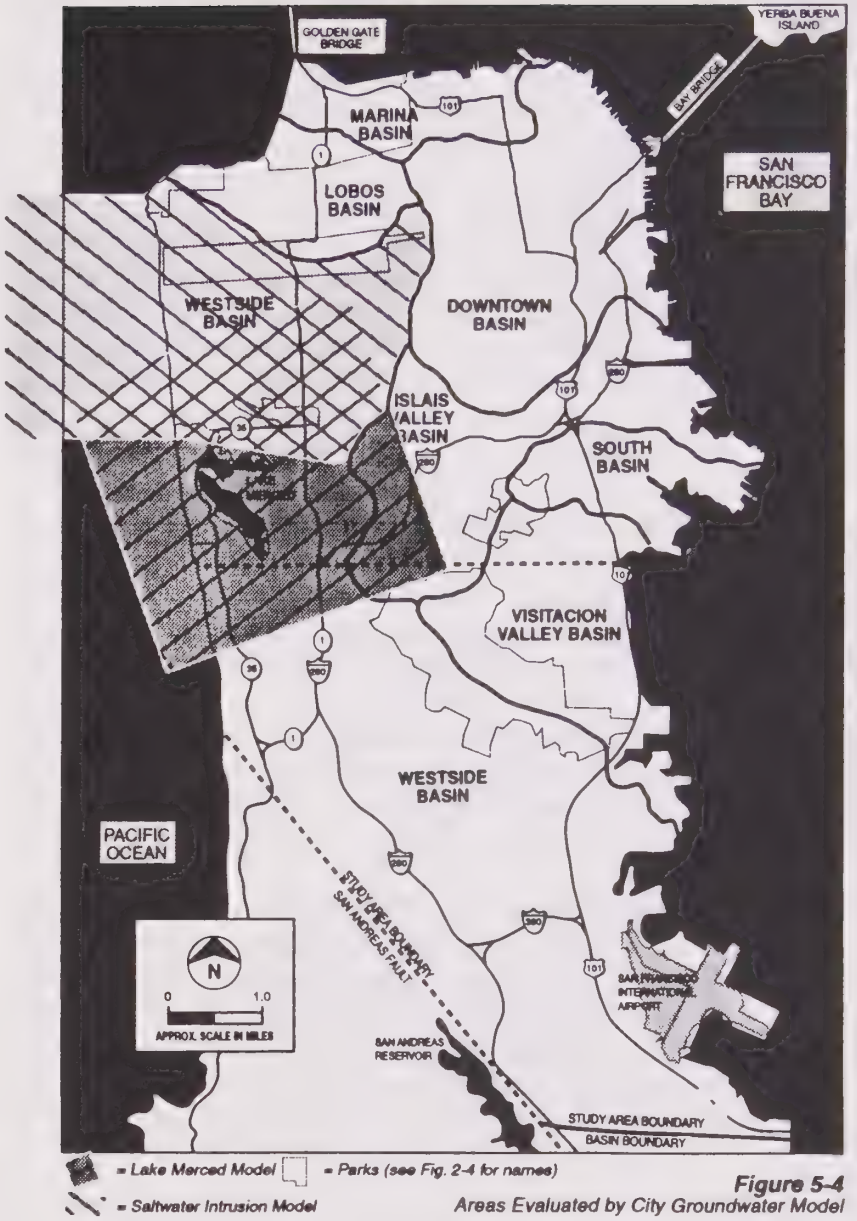


Figure 5-4
Areas Evaluated by City Groundwater Model

- Add imported water directly to the lake
- Add deep aquifer water directly to the lake
- Increase stormwater runoff into the lake
- Substitute recycled water for local groundwater used for irrigation
- Decrease groundwater outflow from Lake Merced to the ocean by recharging coastal groundwater with recycled water

Data provided in the Geo/Resource report (1993) indicate that Lake Merced is the surface expression of the groundwater table (Figure 5-5a). There is no surface water outlet from the lake, and surface water inflow from stormwater runoff is slight or infrequent. As a result, the lake level is very sensitive to groundwater extraction or recharge; water levels in the lake will rise and fall as groundwater levels rise and fall (Figure 5-5b). Groundwater pumping by the municipalities, cemeteries, and golf courses in the vicinity of Lake Merced, the diversion of most runoff that formerly went to the lake, and the recent drought may each have contributed to the declining water levels in the lake. These factors necessitate integrating increasing water levels in Lake Merced with managing the basin and sustaining groundwater levels.

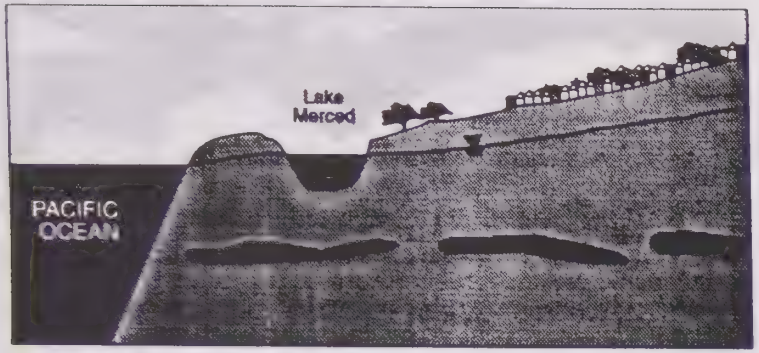


Figure 5-5a
Lake Merced is an Expression of the Local Groundwater Table

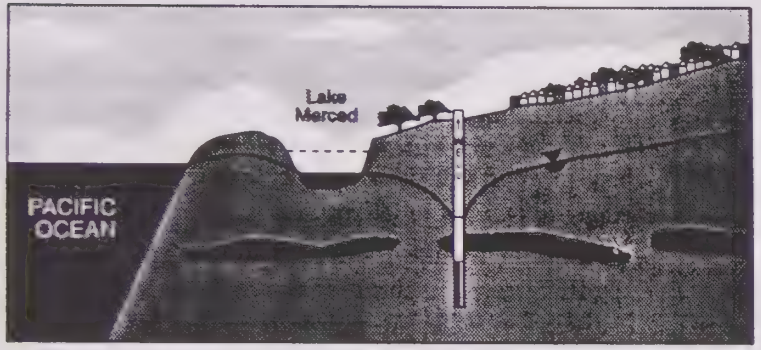


Figure 5-5b
Water Level in Lake Merced is Affected by Local Pumping

The City has attempted an active approach in response to the declining surface water levels in Lake Merced. Twice during 1994 dechlorinated surface water was added to the lake at a daily rate of 5 mgd for periods of 30 days. Data from the USGS recorder in the lake show that this action raised the lake levels between 2 and 3 feet during each event. However, immediately after water addition to the lake ceased, lake levels declined (Figure 5-6), indicating that adding water for short periods of time affects water levels only locally and temporarily and is not a viable alternative for restoring and sustaining water levels at Lake Merced.

The City has recently assessed the ability of the Lake Merced Model to evaluate groundwater management strategies for the Lake Merced area. As part of this assessment, the model was verified using available 1991 to 1993 groundwater data and 1994 data collected during the addition of water to the lake. The validation confirmed the results of the earlier model calibration. The assessment also indicated that the model represents well the average annual changes in lake levels for comparison of relative (although not absolute) benefits of various lake level management strategies. However, the model is able to predict only general trends in water levels changes within the aquifer (not precise changes), especially in areas of high pumping that occur south of Lake Merced. The City will be using the Lake Merced Model in the future to assess alternative water management strategies identified in Activity 3A2 (Conduct modeling to estimate effects of specific groundwater pumping patterns on Lake Merced water levels).

The data used to develop and calibrate the Lake Merced Model where collected by the USGS in the late 1980s as part of a comprehensive groundwater monitoring program for the Lake Merced area. This program ended in 1990 and data collected since then have been sparse. Therefore, the hydrologic data set in the Lake Merced area has some limitations:

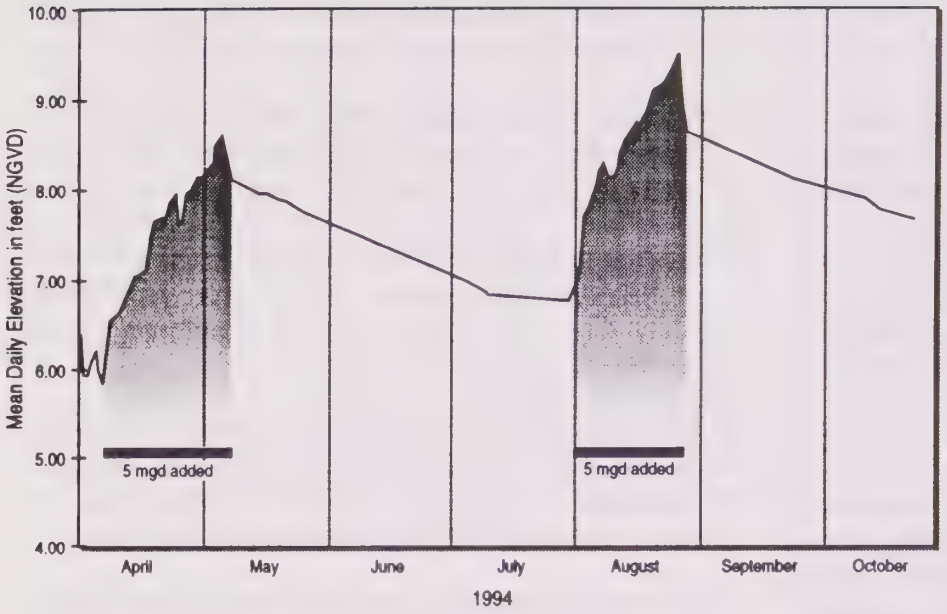


Figure 5-6

SOURCE: USGS Recorder 11162680 Lake Merced at Pumphouse *Changes in the Surface Elevation of Lake Merced (detail of Figure 5-3) Resulting from 5-mgd Recharge*

- There are no data points to measure the hydraulic communication between the shallow aquifer (which includes Lake Merced) and the deep aquifer (where most of the large-scale pumping occurs).
- Adequate pumping records are not maintained by some of the local water users.
- There are few groundwater measuring points that are not in active production wells.
- There are few data points for evaluating the migration of water from the lake to the ocean.

Collection of additional data as part of a comprehensive study of the Westside Basin would accomplish several objectives. First, it would increase the City's understanding of the groundwater system in the vicinity of Lake Merced by incorporating and comparing that data to the data collected previously by the USGS. Second, it would assist in the evaluation of the effectiveness of specific groundwater management approaches on Lake Merced water levels. Finally, it would allow expansion of the existing groundwater model to incorporate the entire Westside Basin and facilitate the model's use as a basin management tool.

The proposed approach to additional data collection includes the following actions:

- Install up to eight additional monitoring wells (two single wells and three well pairs consisting of one well each in the shallow and deep aquifers)
- Collect comprehensive sets of groundwater levels, possibly with one set collected in conjunction with a third period of lake recharge
- Collect pumping records from major groundwater users within the basin
- Incorporate of data into the City's GIS database
- Analyze newly collected data

- Develop groundwater management alternatives for the Lake Merced area

On May 23, 1995, the City's Public Utility Commission adopted Resolution 95-0082 which contained findings and a list of actions that the Commission is prepared to take to arrest the continuing decline in the water level of Lake Merced. The Groundwater and Recycled Water Master Plans will provide the City with relevant information and enable the City to make final decisions regarding the management of groundwater and recycled water in San Francisco.

Continued unmanaged groundwater pumping will cause the water level of Lake Merced to decline further with many deleterious effects. The Commission concluded that cooperative groundwater management efforts, conjunctive operations, substitution of recycled water for groundwater, and better tools to relate groundwater pumping to Lake Merced water levels would help stabilize lake levels. Based upon declining Lake Merced water levels and the activities being pursued to evaluate the situation, the Commission adopted the following actions and activities:

1. The Commission is prepared to take all necessary actions (legal and other) to halt the continued decline in water level of Lake Merced.

2. A conjunctive use program was approved.

3. Staff is to extend planning and groundwater modeling efforts south of San Francisco County line and to formulate a partnership with and seek financial participation with Daly City, San Bruno, and the California Water Service Company.

4. The golf courses in the vicinity of Lake Merced have been asked to determine the suitability of tertiary water from Daly City for golf course irrigation.

5. Staff is to prepare "in lieu" water contracts to deliver in lieu water (from surplus surface water supplies) to Daly City, San Bruno, and the California Water Service Company.

6. Staff is to advise the Commission of the feasibility of banking all or a portion of the potable water made available by the substitution of recycled water for other sources of water in the Merced aquifer.

7. Staff is to develop a plan which evaluates the addition of other sources of recharge water to the Merced aquifer.

Activity 3A2: Conduct Modeling to Estimate Effects of Specific Groundwater Pumping Patterns on Lake Merced Water Levels

Data from Activity 3A1 (Conduct additional field investigation at Lake Merced), the USGS, Bay Area Water Users Association (BAWUA), and other Westside Basin studies will be used to expand the existing model to include the entire Westside Basin. A series of different recharge and pumping scenarios will be modeled and alternative management practices to restore Lake Merced

water levels will be recommended. Potential scenarios to be considered may include:

- What would be the effects of adding 1 mgd, 2 mgd, or 3 mgd to the lake (during nonnesting periods)?

- What would be the effects on the lake if pumping were stopped or reduced and users were supplied imported water?

- What would be the effects on the lake if the golf courses used recycled water? This scenario was tested by Geo/Resource (1993) and would only be re-evaluated if data from Activity 3A1 (Conduct additional field investigation at Lake Merced) indicated different hydraulic conditions.

Management of the Westside Basin is integrally related to the management of water levels at Lake Merced, as stated previously. Ideally, Activities 3A1 and 3A2 will be conducted concurrently with the AB 3030 development conducted under Activity 2C1 (Form appropriate AB 3030 management committee[s]). Each of these activities will provide information to show the importance of managing the basin as a common resource and the mechanism to do so. With the mechanism of AB 3030 in place, the findings of Activity 3A2 will be implementable.

Activity 3A3: Evaluate Relationship Between Other City Lakes and Groundwater

The Water Department will survey lakes and other surface water features (including Pine and Mountain Lakes) within the City and prepare a baseline evaluation of the relationship between each lake, other surface water features, and the local groundwater. Additional monitoring devices (i.e., monitoring wells, staff gauges) may eventually be installed and a database developed for use in evaluating potential future impacts on the City's lakes.

Activity 3A4: Develop and Implement Policies and Procedures to Manage Water Levels in City Lakes

Based on an evaluation of the modeling results for Activity 3A2, the Water Department will develop and implement policies and procedures to manage water levels in City lakes, focusing initially on Lake Merced, Pine Lake, and Mountain Lake. Managing water levels will require cooperation and coordination among the different water users in the areas surrounding these lakes. The Water Department will work closely with the groups formed during Activities 2B1 (Form a City groundwater committee) and 2C1 (Form appropriate AB 3030 management committee[s]) to implement Activity 3A4.

Strategy 3B: Manage Stream Water Levels

Historically, surface water runoff traveled from the hills of the City to San Francisco Bay and the Pacific Ocean via streams and creeks at the bottoms of valleys. With the settlement and development of the City, stream beds were filled or paved. The only remaining unfilled, free-flowing creek in the City is Lobos Creek (see Figure 5-2);

however, the Recreation and Park Department is planning stream restoration in Glen Canyon

Activity 3B1: Assess Effects of Groundwater Development on Lobos Creek

The Water Department is committed to helping preserve the environmental resources provided by Lobos Creek. Lobos Creek's flow of 1.6 mgd (1,800 acre-feet per year) is fed almost entirely by groundwater seepage and is collected by surface diversion and extraction wells to the water treatment plant at the Presidio. Approximately 70 percent of the diverted flow is currently used; the remainder is discharged to the Pacific Ocean. The Water Department has begun to assess the relationship between Lobos Creek and the Lobos Basin and the development potential of the basin. Lobos Creek is managed by the National Park Service.

Proposed development plans for the Presidio under National Park Service management are uncertain at this time.

The Water Department's potential study of the Lobos Basin (Activity 5D1–Develop and implement a study of the Lobos Basin) will provide baseline data to be used in evaluating the potential for groundwater development in the Lobos Basin and its possible effects on Lobos Creek.

Activity 3B2: Evaluate Relationship Between Other City Streams and Groundwater

The Water Department plans to survey other City streams (filled) and prepare a baseline evaluation of the interconnection of the streams with other water bodies within the watershed and with groundwater. This information would help in the evaluation of the potential environmental impacts of groundwater development on streams and may assist the Recreation and Park Department in its stream restoration efforts. The Water Department, in cooperation with other City departments, will identify streams targeted for evaluation. This evaluation may include assessment of historical data, installation of additional monitoring devices (such as monitoring wells) and incorporation of collected data into the Master Plan database.

Activity 3B3: Develop and Implement Policies and Procedures to Manage Water Levels in City Streams

The Water Department will use the information obtained from Activities 3B1 (Assess effects of groundwater development on Lobos Creek) and 3B2 (Evaluate relationship between other City streams and groundwater) to develop and implement policies and procedures to manage water levels in targeted City streams. This effort will include Lobos Creek, which lies within the Presidio, and will require cooperation between the Park Service and the Water Department.

Section Six - Goal 4: Improve Ability to Deliver Water During Emergencies

The Water Department's ability to supply water to both its retail (City) and wholesale (Peninsula, East Bay, and South Bay) customers is at risk during earthquakes, chemical spills, and periods of intense firefighting. As part of this Master Plan, one long-term strategy (Figure 6-1) has been identified whereby groundwater could strengthen the Water Department's ability to react to these potential emergencies.

Strategy 4A: Evaluate Use of Groundwater as an Emergency Reserve

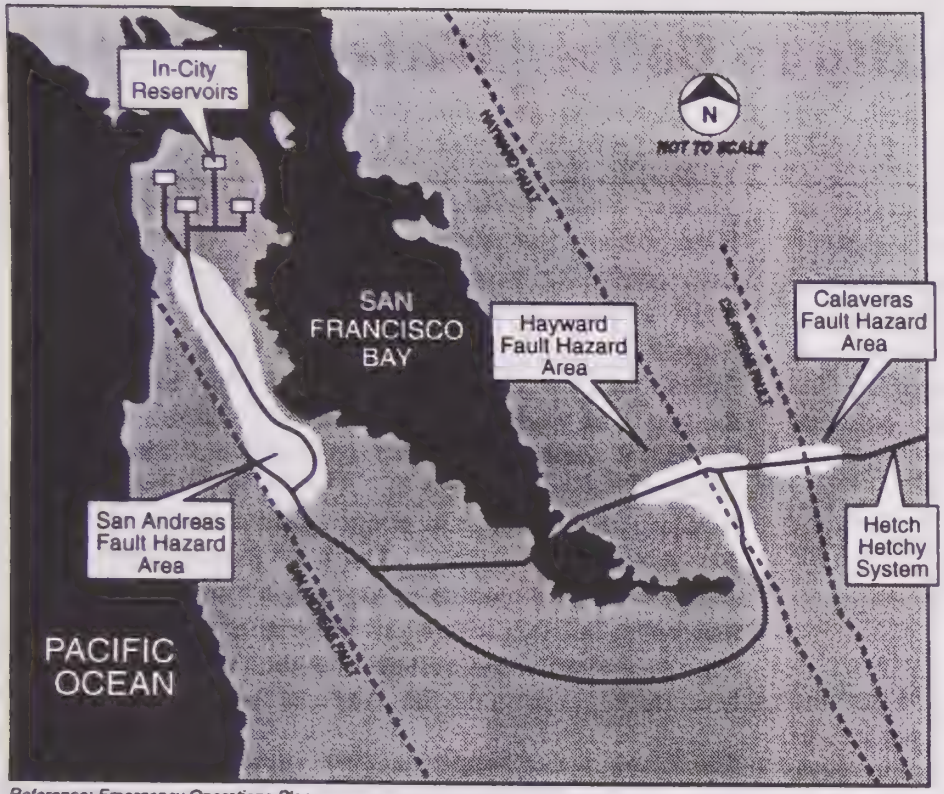
The Water Department and the Hetch Hetchy Water and Power Department deliver approximately 85 percent of their water to customers through transmission lines running from the Tuolumne River Basin to the Bay Area (Figure 6-2). Ten percent of the water delivered to the Water Department's customers comes from East Bay reservoirs (Calaveras and San Antonio Reservoirs) and 5 percent from Peninsula reservoirs (Crystal Springs, Pilarcitos, and San Andreas Reservoirs). The transmission lines conveying water from these sources cross several faults and are vulnerable to damage from earthquakes. According to the Water Department's Emergency Operations Plan (San Francisco Water Department, 1993), the two most vulnerable locations in the system are where the Hetch Hetchy Aqueduct crosses the Calaveras and Hayward Faults (Figure 6-2). A break in the transmission lines at either of these locations could severely affect the Bay Area's water supply. The City maintains a reserve supply of several months by storage in Peninsula and City reservoirs, but this reserve is vulnerable to breaks in the Peninsula distribution system and reservoir infrastructure from earthquakes on the San Andreas Fault system.

The City's water supply is also vulnerable to chemical spills. Crystal Springs Reservoir is crossed by Highway 92 and is vulnerable to accidental spills. If such a spill were to occur, a portion of the City's water supply could be affected. With the exception of Crystal Springs, the watersheds used by the Water Department are isolated and protected from external contamination.

Figure 6-1
Goal 4

Goal	Long-Term Strategy	Short-Term Activity
4. Improve Ability to Deliver Water During Emergencies	4A Evaluate use of groundwater as an emergency reserve	4A1 Study the feasibility of installing large-capacity standby wells 4A2 Design, install and operate large-capacity standby wells, if appropriate 4A3 Update the ater Department's Emergency Operations Plan

DEVELOPMENT AND USE



Reference: Emergency Operations Plan (EQE International, 1993)

Figure 6-2
Location of San Francisco Water Supply Facilities Potentially Vulnerable in an Earthquake

Periods of intensive firefighting can also affect the City's water supply by quickly consuming water available in the City's AWSS and reservoirs. Severe fires can follow a major earthquake, exacerbating water shortages that might already have resulted from the earthquake itself. To prepare for such disasters, the Water Department has identified two short-term activities that could further support existing City emergency plans.

Activity 4A1: Study the Feasibility of Installing Large Capacity Standby Wells

The Water Department will study the feasibility of installing large-capacity wells to supply critically needed potable and nonpotable water in emergencies. These wells would be standby wells that would operate only as needed. The Water Department's current plan is for the large-capacity wells and their associated systems to operate both independently and with the existing water distribution system and the AWSS. Such operational scenarios would provide flexibility and system redundancy for responding to critical water emergencies.

Lake Merced is currently designated as an emergency drinking water supply for the City of San Francisco. However, the City plans to evaluate the potential water quality and health impacts on both Lake Merced and the Westside Basin if tertiary-treated recycled water is added directly to the lake. If addition of recycled water results in changing the designation of Lake Merced from a potable emergency water supply to a nonpotable emergency water supply, the City will need to identify a replacement emergency potable water supply. Large-capacity standby wells could serve as this replacement, depending on the volume of water that can be obtained from the groundwater wells.

If Lake Merced is maintained as an emergency drinking water supply, its water would have to be boiled before use and distributed via portable piping and trucks. Groundwater available for potable use during emergencies would require less treatment than Lake Merced water, which could be used for nonpotable emergency uses, such as for firefighting.

Possible well locations will be identified based on the following:

- Existing information about potential potable and nonpotable water needs of an area
- Timing and supply of recycled water to the area
- Short-term water supply potential of the aquifer
- Groundwater quality conditions
- Compatibility of the location to the existing infrastructure

Activity 4A2: Design, Install, and Operate Large-Capacity Standby Wells, if Appropriate

The Water Department will determine which of the well locations identified in Activity 4A1 (Study the feasibility of installing large-capacity standby wells) will proceed to the design and construct phase of Activity 4A2. Test wells will be installed and tested at each location to verify the initial estimates of potential well yield at that location. If the results are confirmed and meet the needs of the Water Department, further design activities will be conducted. Design specifications for the wells to be installed will include well construction (well depth, pumping capacity, etc.), well housing, and well piping.

Once the wells are installed, operational guidelines will be developed for routine testing and maintenance together with procedures to follow when the wells are operated during emergencies.

Activity 4A3: Update the Water Department's Emergency Operations Plan

The Water Department currently has an Emergency Operations Plan (EOP) (San Francisco Water Department, 1993) for maintaining water distribution during emergencies. This plan could change twice during the implementation of the Master Plan. The first version of the EOP will occur if the designation of Lake Merced as an emergency potable water supply is changed. The second revision will occur at the end of the design of the wells conducted during Activity 4A2. This update will include information on operating the proposed large-capacity standby wells and putting the pumped groundwater into the City's distribution system and/or AWSS. The plan's revisions may also address other groundwater-related emergency strategies developed in response to this Master Plan.

Section Seven - Goal 5: Maximize Groundwater Use

As previously described, groundwater currently supplies a portion of the City's water demand, and the amount supplied could potentially be increased. The Water Department has identified five long-term strategies for increasing groundwater use, as shown in Figure 7-1.

The City's long-term goal is to maximize, to the extent practicable, the amount of groundwater used for beneficial purposes within San Francisco. The term "maximize groundwater use" means that the City's goal is to undertake a set of long-term actions that will increase the use of groundwater without overriding cost, customer response, or risk to groundwater quality and quantity. Short-term activities are suggested that increase groundwater use at moderate exposure to the potential effects noted above. Long-term activities will build on the lessons learned during the implementation of the short-term activities.

San Francisco fully intends to develop comprehensive groundwater management programs to meet the water resources needs and obligations of the 21st century. The lessons learned and the success of the City's efforts will set an example that will encourage its wholesale customers to implement similar programs.

The Water Department used a number of criteria to evaluate the feasibility of implementing each short-term activity involving groundwater extraction and distribution. These criteria included the cost of developing and delivering the groundwater, potential customer response to receiving groundwater or a blend of surface water and groundwater, the technical feasibility of an activity, and the availability of groundwater in the basin under current groundwater conditions (recognizing that the Water Department would develop, at most, less than the average annual recharge shown in Table 2-2; however, artificially increasing recharge to a basin could increase the amount of available groundwater). Each of these strategies and the short-term activities the Water Department may implement are summarized following a discussion of potential groundwater users.

Potential Groundwater Users

The Water Department focused on the four groups of City water users who would be potential groundwater customers. These groups are:

- Individual nonpotable users
- Individual potable users
- Local distribution system users
- Main distribution system users

The individual nonpotable user group is the same group of users identified in the Recycled Water Master Plan as possible recipients of recycled water. The Water Department recognizes that its potable users could notice taste differences between the surface water they currently receive and groundwater. To minimize the potential for such taste changes, the Water Department would blend the surface water and groundwater before supplying it to its customers during nonemergency operations. The Water

Figure 7-1
Goal 5

Goal	Long-Term Strategy	Short-Term Activity
5. Maximize Groundwater Use	5A Capture groundwater outflow to the San Francisco Bay or Pacific Ocean	5A1 Extract groundwater from Elk Glen Well; add to main distribution system 5A2 Extract groundwater from the Sunset District, add to main distribution system
	5B Capture groundwater produced by dewatering operations	5B1 Add groundwater to the AWSS from dewatering at the Powell Street BART 5B2 Identify permanent dewatering operation in the City and identify potential beneficial uses for the water 5B3 Develop procedures to put temporary construction dewatering water to beneficial use 5B4 Evaluate the feasibility of using, and implement if appropriate, the existing sludge line to convey non-potable water to the North Point plant
	5C Operate groundwater basins conjunctively	5C1 Conduct in-lieu recharge of the southern portion of the Westside Basin 5C2 Conduct conjunctive use in the Lobos Basin
	5D Investigate other groundwater basins	5D1 Develop and implement a study of the Lobos Basin 5D2 Develop and implement studies of other shared and City basins
	5E Evaluate other potential activities for increasing groundwater use	5E1 Evaluate, and implement where feasible, potential groundwater use in the City's fountains and decorative pools 5E2 Evaluate, and implement where feasible, the potential for groundwater to help control corrosion in the City's water distribution system

Department also identified two groups of distribution system users based on the premise that groundwater is most economically delivered when a greater number of users can be served with the fewest facilities.

Individual Nonpotable Users. Nonpotable uses of groundwater include irrigation of large landscaped areas (such as parks, golf courses, and athletic fields), toilet flushing and cooling in commercial areas, firefighting, and decorative fountains (Figure 7-2). As noted previously, the Water Department and the Department of Public Works are planning the coordinated use of groundwater and recycled water throughout the City. In the future, water from three sources may be available for nonpotable users, to be supplied according to the following general priorities: first, recycled water; second, groundwater (where recycled water is unavailable or inappropriate); and finally, surface water (where both recycled water and groundwater are unavailable or inappropriate). However, the actual source of a user's nonpotable supply would

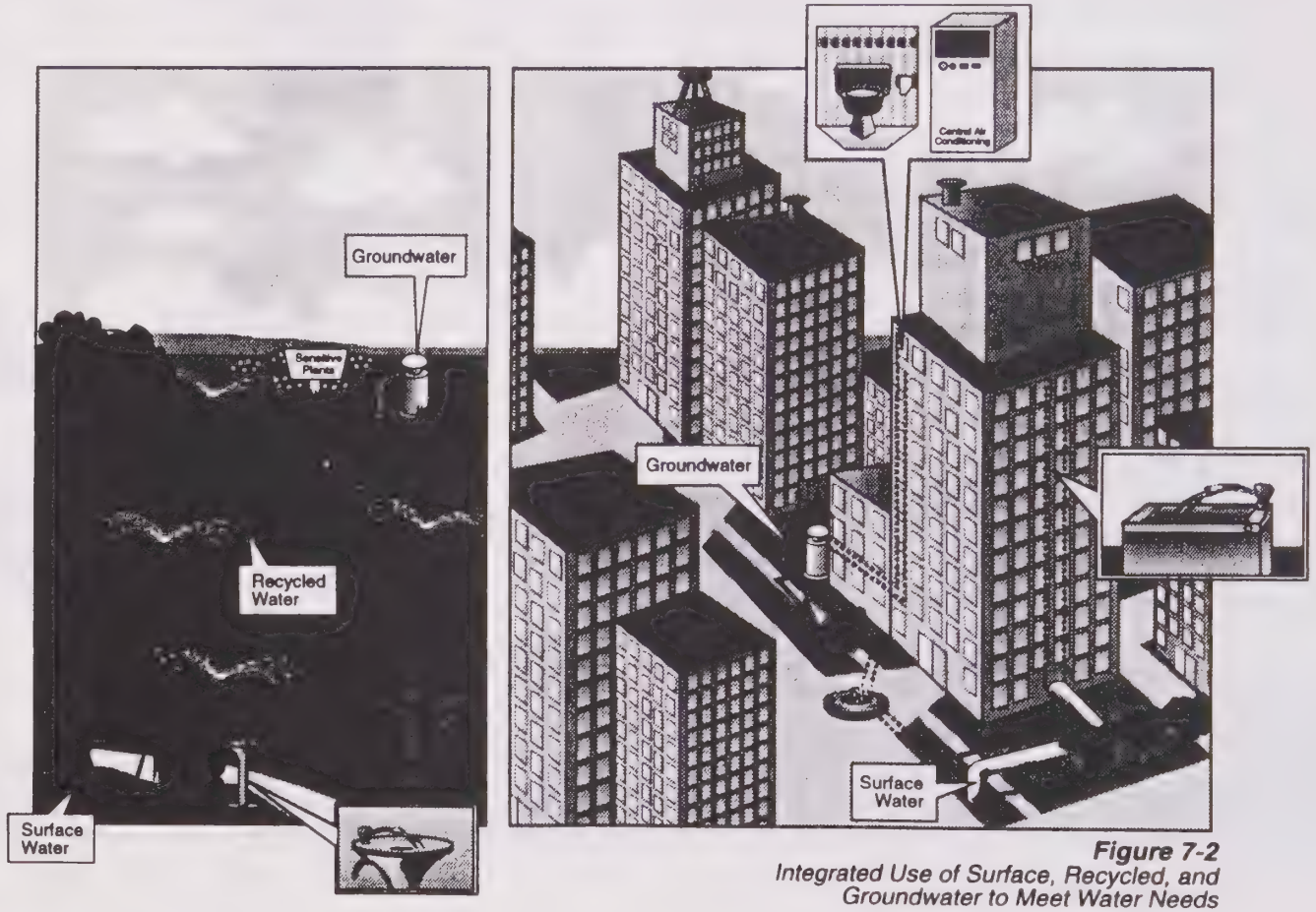


Figure 7-2
Integrated Use of Surface, Recycled, and Groundwater to Meet Water Needs

depend on a number of factors, including economics and water quality requirements.

In San Francisco, the large users of nonpotable water are Golden Gate Park, the zoo, and the golf courses near Lake Merced. These users are targeted to receive recycled water to fill all or part of their nonpotable water needs by the year 2000. Between 1995 and 2000, users currently receiving groundwater would continue to do so. Small nonpotable users are the large buildings in the Downtown Basin. Groundwater would be considered as a potential supply for nonpotable users in large buildings in the Downtown Basin because recycled water will not be delivered there.

Individual Potable Users. For purposes of this Master Plan, individual potable users are those for whom the Water Department could extract, treat, and deliver groundwater directly as potable water (Figure 7-3). Schools and large retail or commercial complexes (e.g., commercial laundries) are examples of such potential users.

Local Distribution System Users. As shown in Figure 7-4, local distribution system users are connected to the City's water mains measuring 12 inches in diameter and less. For these users, the Water Department could extract, treat, and inject groundwater into the local distribution system where it would blend the groundwater with the surface water already in the system.

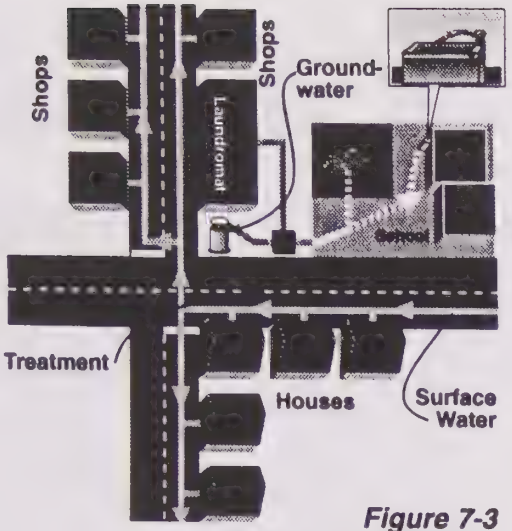


Figure 7-3
Use of Groundwater for Individual Potable Uses

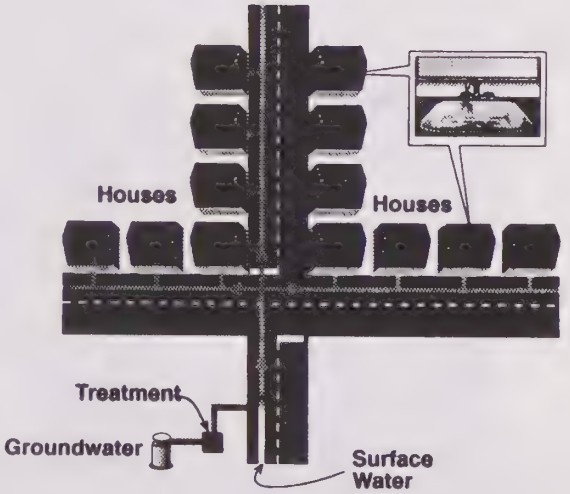


Figure 7-4
Use of Groundwater in the Local Distribution System

Main Distribution System Users. Main distribution lines are 16 inches in diameter or greater and are used to transport water around the City. No users are connected directly to the City's water mains, but some are supplied water from the main distribution system by feeder lines measuring 6 or 8 inches in diameter. The Water Department could extract and either treat or blend groundwater (if it does not meet drinking water standards) with surface water before injecting the blended water into the main distribution system, or inject groundwater directly into the main distribution system (if it meets drinking water standards) where the two water sources would be blended.

Strategy 5A: Capture Groundwater Outflow to the San Francisco Bay or Pacific Ocean

In San Francisco groundwater basins, annual recharge is provided through both natural (rainfall) and incidental (pipe losses and irrigation return flow) processes. As noted in Section 2, the estimated amount of average annual recharge in each basin generally exceeded groundwater withdrawal in 1993. Recharge not captured by pumping becomes part of the subsurface groundwater reservoir, which discharges into the Pacific Ocean or the San Francisco Bay, depending on the basin's location (Figure 7-5).

The following discussion summarizes known information on groundwater outflow from each basin and presents the approach used to identify potential projects being considered further by the Water Department.

Westside Basin. The Westside Basin has the most subsurface outflow available for capture. Currently, about 2,500 acre-feet of groundwater is extracted from the northern portion of the Westside Basin, primarily in Golden Gate Park and at the zoo and golf courses near Lake Merced. Based on an estimated average recharge of 4,900 acre-feet per year, a portion of the additional 2,400 acre-feet of groundwater could be withdrawn from parts of the northern portion of the Westside Basin without adverse impacts within the basin. A portion of this water, used primarily for irrigation in Golden Gate Park and irrigation and pool-filling at the zoo, is scheduled to be replaced with

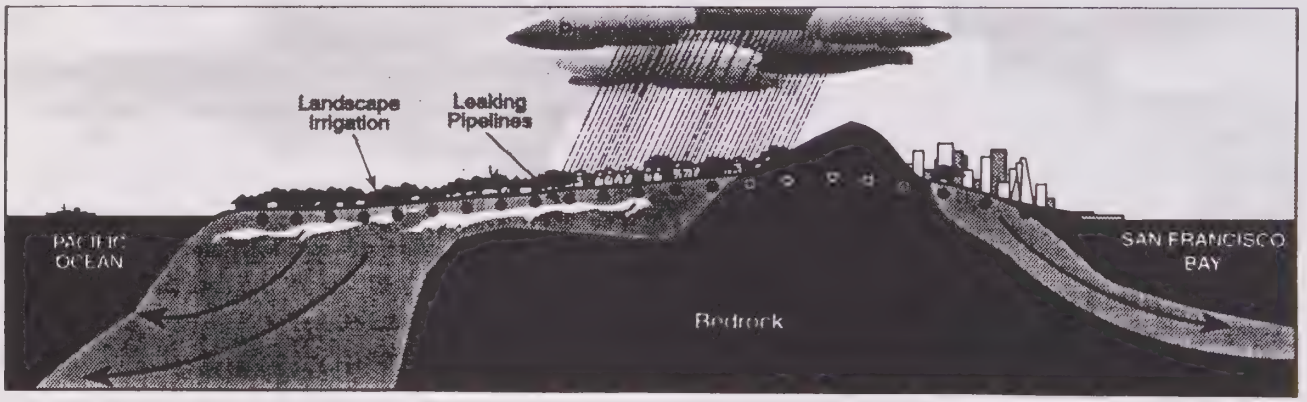


Figure 7-5
Groundwater Recharge in San Francisco

recycled water in the year 2000. Draft master plans prepared for both Golden Gate Park (San Francisco Recreation and Park Department, 1994) and the zoo (City and County of San Francisco, Department of Public Works, 1994) specify the water supply needs of both areas. Once these areas are supplied with recycled water, all or part of the replaced water could by used for other development projects. The Water, Recreation and Park, and Public Works Departments will work together to coordinate these water use projects.

Downtown Basin. The Downtown Basin is the second largest basin in the City (after the Westside Basin) and the largest on the east side. It is about 200 feet deep (relatively shallow compared to the Westside Basin, which is 3,500 feet deep) and has an estimated existing recharge of 5,900 acre-feet per year. Approximately 800 acre-feet per year of documented groundwater extraction occurs in the Downtown Basin from current dewatering operations (although the Department of Public Works estimates that dewatering operations contribute an average of 5,600 acre-feet per year to sewer flow). Future groundwater development in the Downtown Basin depends on a number of issues such as the high potential for land subsidence and water quality within the basin. Therefore, for the purposes of this Master Plan, the Water Department is considering only Downtown Basin activities that would use groundwater extracted from dewatering operations in a nonpotable manner (e.g., toilet flushing, wash water, and climate control). These activities are discussed as part of Strategy 5B.

Lobos Basin. Based on existing recharge estimates using 1987-1988 water level data, groundwater extraction in the Lobos Basin (primarily at the Presidio) exceeds existing recharge (Table 2-2). However, these numbers may be low because the estimated amount of existing recharge is not exact and data used in its calculation were from drought years. Additional groundwater development in the Lobos Basin may be possible. The Water Department is working to verify the existing recharge estimate and to determine the potential for additional groundwater development in the Lobos Basin (Activity 5D1–Develop and implement a study of the Lobos Basin).

Other Basins. Insufficient information is available regarding the aquifers in the Marina, Islais Valley, South, and Visitacion Valley Basins. Additional information is required regarding existing water quality and aquifer characteristics so that the Water Department can identify potential potable and/or nonpotable uses for the groundwater within these basins.

Approach to Identifying Groundwater Development Activities. Based on the Water Department's preliminary evaluation, the Westside Basin has the greatest potential to capture groundwater outflow. Water from the tested areas within the basin is potable, annual recharge is greater than annual use in the northern portion of the basin, and a portion of the current use will be converted to recycled water in the year 2000. This will allow for development of the replaced groundwater for other uses. Table 7-1 summarizes activities the Water Department preliminarily considered for capturing and using a portion of the 4,900 acre-feet per year of the annual recharge within the northern part of the Westside Basin. The Water Department will meet the needs of Golden Gate Park before implementing the activities discussed in the following sections.

Table 7-1
Potential Activities to Capture Groundwater Lost to the San Francisco Bay or Pacific Ocean in the Northern Portion of the Westside Basin

User Group	Activity	Assumption	Benefit	Amount (ac-ft/yr)	Potential Constraints
Individual NonPotable Users (Without Treatment)	Install well at Ocean View Playground	Onsite location for well exists	Replace imported potable supply being used for nonpotable with groundwater	20	Incentive to user?
	Install well at West Sunset Playground	Onsite location for well exists	Replace imported potable supply being used for nonpotable with groundwater	39	Incentive to user?
	Install well at Laguna Honda Home	Onsite location for well exists	Replace imported potable supply being used for nonpotable with groundwater	8	Incentive to user?
Individual Potable Users (With Treatment)	Install well at St. Mary's Hospital	Onsite location for well and chlorination exists	Replace imported potable supply with groundwater	110	Minimum blend
	Install well at State of California, Font Boulevard	Onsite location for well and chlorination exists	Replace imported potable supply with groundwater	156	Located close to Lake Merced; minimum blend
	Install well at Stonestown Properties	Onsite location for well and chlorination exists	Replace imported potable supply with groundwater	96	Located close to Lake Merced; minimum blend
	Install well at San Francisco State	Onsite location for well and chlorination exists	Replace imported potable supply with groundwater	88	Located close to Lake Merced; minimum blend
	Install well at Lake Merced Sports Center	Onsite location for well and chlorination exists	Replace imported potable supply with groundwater	48	Located close to Lake Merced; minimum blend
Local Distribution System Users (With Treatment)	Install two or three wells near 44th, and inject into local pipeline	Well and chlorination sites exist	Supply additional potable water to Water Department system	800-900	Medium blend; affects local neighborhood
	Operate Elk Glen Well for maximum extraction amount, inject into local pipeline	Existing well is okay for production of potable water or would cost minimal amount to improve; Elk Glen area can sustain higher levels of pumping	Supply additional potable water to Water Department system	500-900 [0-500 ac-ft/yr rec and park use at Elk Glen]	Medium blend; affects local neighborhood
	Construct new well at Elk Glen location, inject into local pipeline	Elk Glen irrigation well unsuitable for production and therefore retired; Elk Glen area can sustain higher levels of pumping	Supply additional potable water to Water Department system	500-900 [0-500 ac-ft/yr rec and park use at Elk Glen]	Medium blend; affects local neighborhood
Main Distribution System Users (With Treatment)	Install two or three wells near 44th and extend piping up to large-diameter piping going out of Sunset Reservoir	Well and chlorination sites exist	Supply additional potable water to Water Department system	800-900	
	Operate Elk Glen Well for maximum extraction amount, inject into local pipeline	Existing well is okay for production of potable water or would cost minimal amount to improve; Elk Glen area can sustain higher levels of pumping	Supply additional potable water to Water Department system	500-900 [0-500 ac-ft/yr rec and park use at Elk Glen]	
	Construct one well south of Golden Gate Park near 23rd, inject into large-diameter main	Well and chlorination sites exist	Supply additional potable water to Water Department system	800	Potential alternative if existing Elk Glen Well is not suitable
	Convert existing deep monitoring well at Stern Grove into production well, inject into large-diameter main	Well is convertible from monitoring well	Supply additional potable water to Water Department system	1,100	Located close to Lake Merced
	Construct new well at Stern Grove, inject into large-diameter main		Supply additional potable water to Water Department system	1,100	Located close to Lake Merced

Note: Shaded activities are discussed in the text of this report. Those not shaded were not considered further and may be considered in future projects.

As shown in Table 7-1, three Westside Basin activities could use groundwater to supply individual, nonpotable users who will not receive recycled water; five activities could supply groundwater to individual potable users; three activities could supply groundwater to potable users via the local water distribution system; and five activities could supply groundwater to potable users via the main water distribution system. Each of these activities is in an area where groundwater has been tested and found to be potable (although additional water quality sampling would be needed to verify that extracted groundwater meets all drinking water criteria).

Using five criteria, the Water Department selected two short-term activities (the projects are shaded) from the 16 activities summarized in Table 7-1 for further consideration. Those projects not selected may be considered in the future. The criteria used were as follows:

- **Cost of Producing Water**–Figure 7-6 shows how the cost of producing water varies per acre-foot for each of the 16 activities considered. The cost of producing and distributing the water was not the sole criterion for choosing the short-term activities; the Water Department also considered the present and future economic state of the City in making its decision.

- **Basin Yield**–As mentioned above, the northern portion of the Westside Basin may be able to yield a part of the 2,400 acre-feet of annual groundwater recharge that is currently not being used. The total groundwater extractions for the activities and current use cannot exceed 4,900 acre-feet per year. However, because of the declining water levels at Lake Merced, projects were not selected that would increase the amount of groundwater extracted from the lake's immediate vicinity.

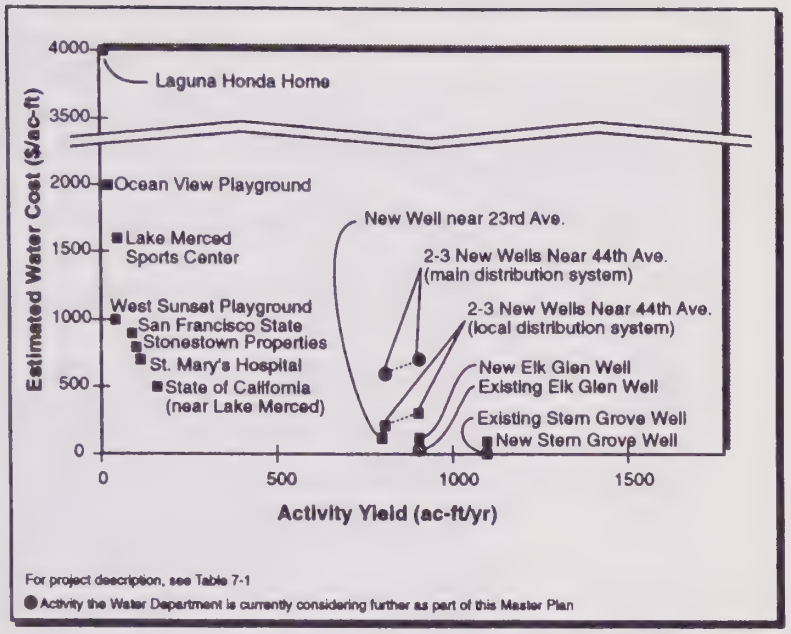


Figure 7-6
Range of Potential Activity Costs in Westside Basin (northern portion)

- **Technical Feasibility**–In selecting the activities to consider further, the Water Department evaluated the feasibility of installing new wells and using existing wells. Extraction wells need to be placed to avoid saltwater intrusion, to minimize pumping effects on the water levels at Lake Merced and other surface water bodies in the area, and to be suitably positioned within the aquifers to extract large volumes of groundwater (i.e., areas with large saturated thicknesses and high hydraulic conductivities).

- **Location of User**–Activities designed to serve individual users had to be located in areas that were technically feasible. In addition, developing systems for individual users who plan to use recycled water in the long-term was not practical; therefore, potential individual users had to be committed to long-term groundwater use.

- **Location Relative to Existing Distribution Network**–For activities where groundwater is to be sent to more than one user, the location of the activity became important. The closer the new or existing wells were to the existing water distribution system, the less infrastructure would be needed and the lower the cost of producing water.

Activity 5A1: Extract Groundwater from Elk Glen Well; Add to Main Distribution System

Use of the existing Elk Glen Well (Figure 7-7) for groundwater extraction was selected based on the estimated low cost of the water produced (See Figure 7-6) and the short time required for implementation. Implementation of this activity depends, however, on (1) the concurrence of the Recreation and Park Department and its coordination of use of the well until recycled water is available, and (2) verification that the well meets municipal well construction standards. If neither of these conditions can be met, a new well may be constructed adjacent to the existing wells or at an alternative location, providing groundwater at a slightly higher cost and with a longer implementation period. Groundwater extracted from the Elk Glen Well would be chlorinated and added to the main distribution system (30-inch-diameter pipeline) where it would blend with imported water before distribution to potable water users. If the existing Elk Glen Well is not used for groundwater extraction, it may be used for monitoring purposes or as a backup well, or it may be abandoned, depending on its design or current condition.

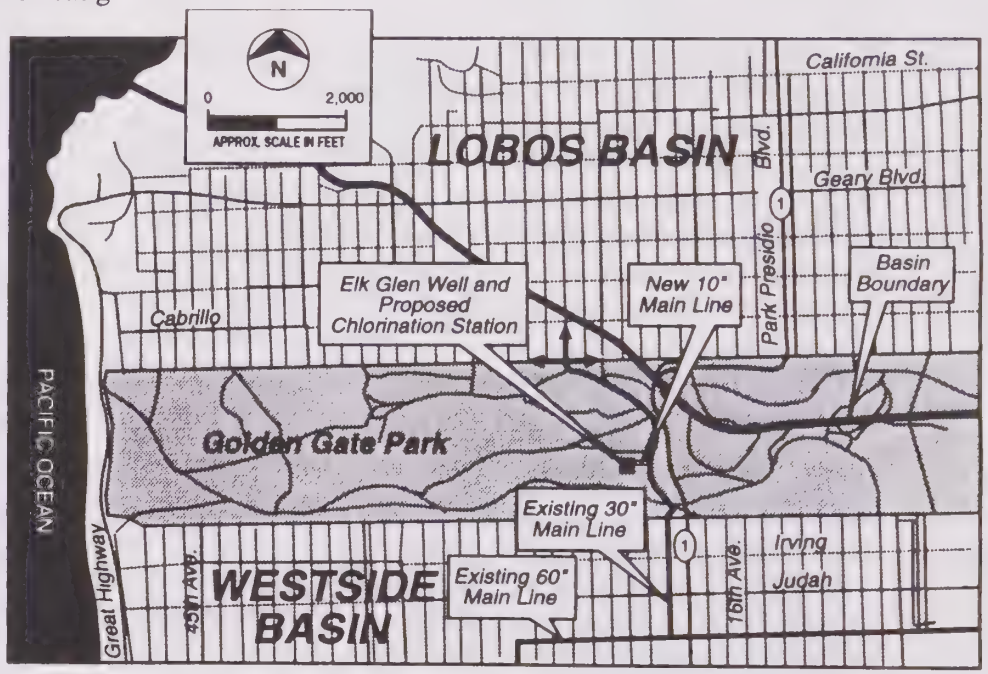


Figure 7-7
Conceptual Configuration, Activity 5A1

Additional testing is needed to confirm the water quality at the Elk Glen Well. One sample in 1990 indicated that nitrate levels in groundwater were slightly above the maximum contaminant level (MCL) of 45 milligrams per liter (mg/L); in a subsequent sampling event in 1993, nitrates were below the MCL. If groundwater at the Elk Glen Well does not meet Title 22 Drinking Water Standards, additional treatment or blending may be required prior to injection into the main distribution system. If drinking water standards are met, California Department of Health Services will allow direct injection of groundwater into the system.

Activity 5A2: Extract Groundwater from the Sunset District; Add to Main Distribution System

The Water Department will install two to three new municipal wells in the Sunset District in the vicinity of 44th Avenue (Figure 7-8). These wells will each pump an estimated 200-250 gallons per minute (gpm). The results of Activity 1A1 (Evaluate potential for saltwater intrusion) will be used to finalize the location and rate of operation of the proposed wells.

Groundwater extracted by these new wells will be chlorinated and then added to the main distribution system where it will blend with the surface water already in the system before distribution to City users. This activity is a cost-effective way to develop a groundwater supply and minimize the potential change in taste.

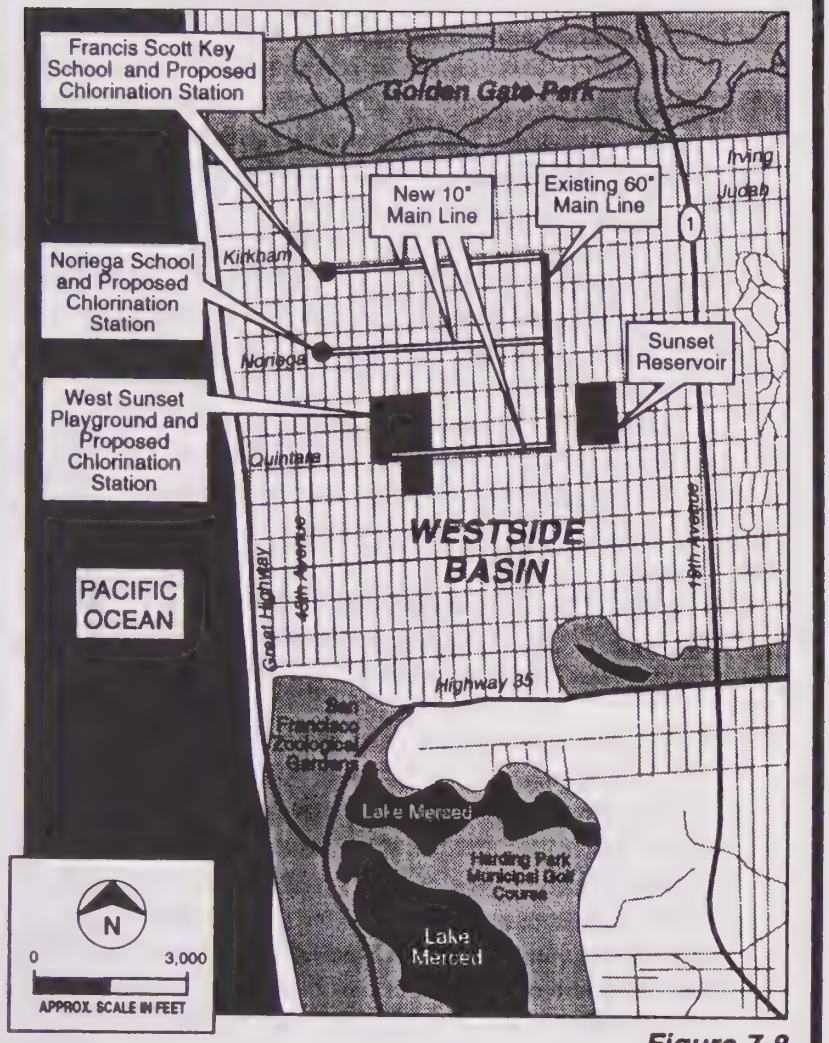


Figure 7-8
Conceptual Configuration, Activity 5A2

Strategy 5B: Capture Groundwater Produced by Dewatering Operations

Groundwater levels in many parts of the Downtown Basin are high. In many low-lying portions, groundwater levels are higher than basements, and pumping is required to keep basements or subsurface facilities dry, such as Bay Area Rapid Transit (BART) stations (Figure 7-9). Although some facilities, such as the California State Automobile Association Building at 100 Van Ness Avenue, have installed dual plumbing systems to use the extracted groundwater for nonpotable uses, in most cases the groundwater is disposed of in the sewer.

Table 7-2 summarizes activities the Water Department evaluated for capturing groundwater extracted by dewatering operations. Nine of these activities could supply dewatering water to individual nonpotable users (recycled water is not planned for the Downtown Basin area), and for one activity dewatering water could be added to the City's AWSS to be used for firefighting.

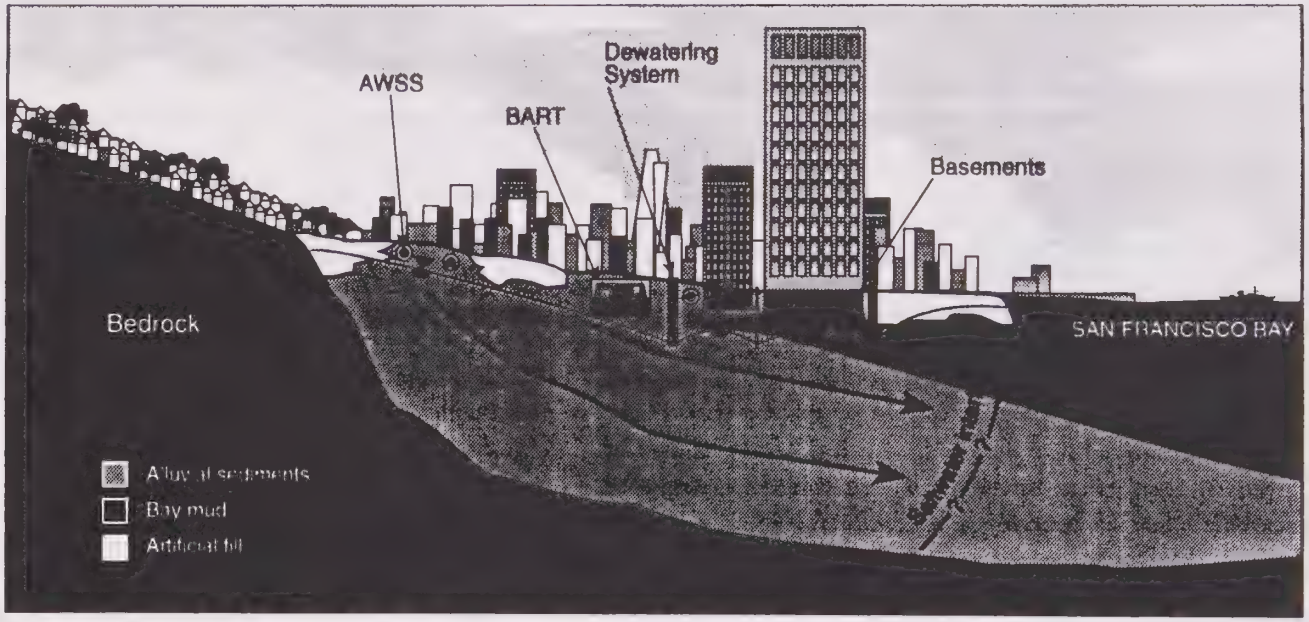


Figure 7-9
High Groundwater Levels In the Downtown Basin

Table 7-2
Potential Activities for Capturing Groundwater
Produced by Dewatering Operations (Downtown Basin)

User Group	Activity	Assumptions	Benefits	Amount (ac-ft/yr)	Potential Constraints (Institutional)
AWSS Network Users (Without Treatment)	Put water from Powell St. BART and other dewatering sites to AWSS		Replace imported potable supply being used for nonpotable with groundwater	225	Fire Dept. cooperation needed
Individual NonPotable Users (Without Treatment)	Install well at Alta Plaza Park	Onsite well location exists	Replace imported potable supply being used for nonpotable with groundwater	24	Incentive to User? Water Quality Issues; Lack of Distribution System
	Install well at Civic Center Plaza	Onsite well location exists	Replace imported potable supply being used for nonpotable with groundwater	12	Incentive to User? Water Quality Issues; Lack of Distribution System
	Install well at Hamilton Playground	Onsite well location exists	Replace imported potable supply being used for nonpotable with groundwater	9	Incentive to User? Water Quality Issues; Lack of Distribution System
	Install well at Jefferson Square	Onsite well location exists	Replace imported potable supply being used for nonpotable with groundwater	11	Incentive to User? Water Quality Issues; Lack of Distribution System
	Install well at Kimball Playground	Onsite well location exists	Replace imported potable supply being used for nonpotable with groundwater	10	Incentive to User? Water Quality Issues; Lack of Distribution System
	Install well at Margaret Hayward Playground	Onsite well location exists	Replace imported potable supply being used for nonpotable with groundwater	10	Incentive to User? Water Quality Issues; Lack of Distribution System
	Install well at Union Square	Onsite well location exists	Replace imported potable supply being used for nonpotable with groundwater	6	Incentive to User? Water Quality Issues; Lack of Distribution System
	Install well at Moscone Center	Onsite well location exists	Replace imported potable supply being used for nonpotable with groundwater	50	Incentive to User? Water Quality Issues; Lack of Distribution System
	Use existing stubpeline to North Point WWTP	DPW will be restoring line	Provide nonpotable to WWTP for [illegible]	Unknown	The line is discontinuous

Note: Shaded activities are discussed in text of this report. Those not shaded were not considered further and may be considered in future projects.

As described for the activities considered to capture groundwater outflow in the Westside Basin, the Water Department chose to investigate further those activities that met a number of criteria. These criteria included a reasonable cost of producing and distributing the water, technical feasibility, water quality, and the proximity of the users and the distribution system to the location of the dewatering systems. Based on these criteria, the Water Department has elected to pursue the two activities shaded in Table 7-2. In addition, two other activities may identify potential sources of dewatering water in the Downtown Basin.

Activity 5B1: Add Groundwater to the AWSS from Dewatering at the Powell Street BART

In this activity, the Water Department will capture groundwater from the Powell Street BART dewatering system and put it in the AWSS for the Fire Department to use for firefighting. An estimated 150 acre-feet per year (based on December 1990 flow rates) can be captured from the Powell Street BART Station for beneficial use.

During periods of nonuse, the AWSS requires an average of 225 acre-feet per year of water to compensate for normal pipeline leakage and to maintain adequate pressure within the system. This activity provides a dual benefit because it reduces the amount of treated water added to the AWSS and reduces the water currently added to the sewer by the dewatering operation. The Water Department is coordinating with the Fire Department regarding implementation of this activity.

Activity 5B2: Identify Permanent Dewatering Operations in the City and Identify Potential Beneficial Uses of the Water

Many sites in the City are known to be undergoing dewatering. During Activity 5B2, these sites will be identified, where possible. Beneficial uses of this water will be further evaluated to identify cost-effective and technically feasible options. Water quality testing will be needed at each of the sites (possibly in conjunction with the Regional Water Quality Control Board) to determine limitations of use or needed treatment. As will be the case with Activity 5B1, use of dewatering water for beneficial nonpotable uses will also reduce the amount of water sent to the sewer for treatment.

Activity 5B3: Develop Procedures to Put Temporary Construction Dewatering Water to Beneficial Use

Temporary (duration of days to months) dewatering is also common during construction of buildings, pipelines, or other activities with deep excavations. Procedures will be developed that could be incorporated into applications for building permits and other project approval permits to require evaluation of potential beneficial uses for water produced during temporary dewatering operations. These procedures would include testing requirements and possible beneficial uses to be considered by the applying contractor in a building permit application.

Activity 5B4: Evaluate the Feasibility of Using, and Implement if Appropriate, the Existing Sludge Line to Convey Non Potable Water to the North Point Plant

Some activities at the North Point Wastewater Treatment Plant currently use potable water and could use nonpotable water if it could be supplied to the plant. The primary plant use of this nonpotable water is flushing of the sedimentation tanks (six tanks with a volume of 850,000 gallons each).

A former sludge line runs from the intersection of Army and Indiana Streets to the North Point plant. The integrity of this line was tested in 1992 (City of San Francisco,

1994), but the results were inconclusive. Portions of the line are being relocated or replaced by the Department of Public Works and the California Department of Transportation (Caltrans). This work is expected to be completed by 1996, after which this line could be retested to see if it is usable as a means of transporting nonpotable water obtained from Activities 5B2 or 5B3 to the North Point Plant. This would provide beneficial uses for water from dewatering operations and would reduce the potable water demand at the plant.

Strategy 5C: Operate Groundwater Basins Conjunctively

The Water Department and the other entities in shared groundwater basins have identified conjunctive use of groundwater basins as a long-term strategy that could help meet the goal of increasing groundwater use. Conjunctive use of water resources is the planned and coordinated use of groundwater and surface water supplies. In the City's case, one potential implementation of conjunctive use strategy is use of groundwater basins as storage reservoirs by directly recharging the basins with water during wet years when surplus water is available, and using the groundwater for potable water supply during dry years when other water supplies are limited (Figure 7-10). A second potential conjunctive use approach is in-lieu recharge, where surface water is supplied to a groundwater user during periods when surplus surface water is available. The groundwater that remains in storage (i.e., is not pumped) is then extracted during years of need.

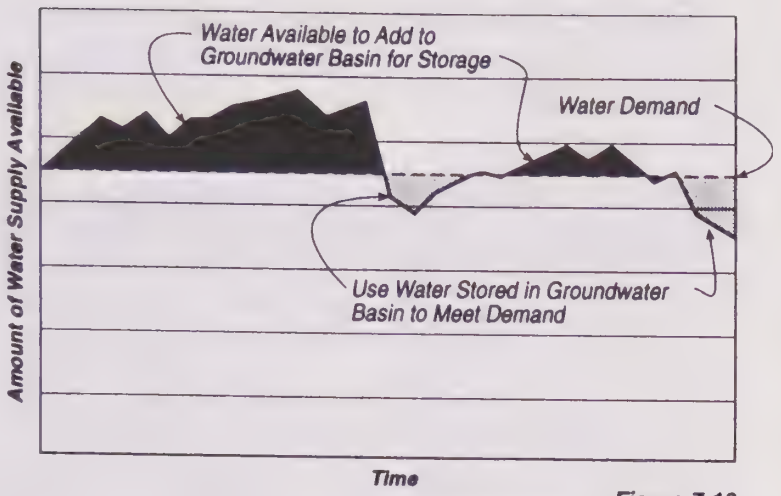


Figure 7-10
Conceptual Approach to Conjunctive Use of San Francisco's Groundwater Basins

Subsurface outflows to the San Francisco Bay or the Pacific Ocean from each basin could be captured and used to replace or augment existing surface water supplies. Surplus surface water could also be used for recharge water.

Preliminary evaluations of the potential application of conjunctive use strategies have been conducted by the Water Department for three basins: Westside, Lobos, and Downtown. Both the Westside and the Lobos Basins have been identified by the Water Department as having high potential for implementing potable water conjunctive use strategies. The Water Department has developed activities to evaluate each of these two basins for conjunctive use opportunities. Conjunctive use within the Downtown Basin is not considered further by the Groundwater Master Plan because the water in the Downtown Basin is nonpotable and the infrastructure to transport nonpotable

water within the Downtown Basin is not planned as part of the Recycled Water Master Plan (City and County of San Francisco, 1995).

Activity 5C1: Conduct In-Lieu Recharge of the Southern Portion of the Westside Basin

The Water Department has discussed with the Cities of Daly City and San Bruno and with the California Water Service Company the potential development of an in-lieu recharge program for the southern portion of the Westside Basin. The purpose of this program is to minimize potential impacts from intensive groundwater pumping and promote recovery of drought-depleted groundwater reserves. One option being considered is for the Water Department to provide surface water to pumpers in the southern portion of the Westside Basin in exchange for their ceasing or reducing their pumping of groundwater and allowing the aquifer to recharge. The stored water would be withdrawn by the pumpers during periods of surface water supply shortages in lieu of purchasing a like amount of water from the Water Department. This water exchange could provide relief to declining Lake Merced water levels.

Activity 5C2: Conduct Conjunctive Use in the Lobos Basin

The City will evaluate the Lobos Basin to determine the most appropriate approach to implementing conjunctive use practices there. Existing information, findings from Activities 5D1 (Develop and implement a study of the Lobos Basin) and 3B1 (Assess effects of groundwater development on Lobos Creek), and needs of the Water Department will be used to evaluate the approach to managing the groundwater resources of the Lobos Basin. Possible approaches to the conjunctive use of the basin include in-lieu recharge by supplying surface water to replace the direct groundwater extraction by the Park Service (estimated to be 530 acre-feet per year) or direct recharge of surplus surface water supplies for long-term storage. Injection wells will be considered as a possible method of directly recharging the basin.

Strategy 5D: Investigate Other Groundwater Basins

As discussed in Section 2, groundwater in the Marina South, Visitacion Valley, and Islais Valley Basins is generally undeveloped, and data on hydrogeologic properties and water quality are limited. Additional investigations are needed in these basins to determine whether there are potential potable or nonpotable groundwater uses within each of them. A hydrogeologic investigation is also planned for the Lobos Basin to evaluate the additional groundwater development potential of the basin. The Water Department has therefore identified two short-term activities for further investigation of these City groundwater basins for future development.

Activity 5D1: Develop and Implement a Study of the Lobos Basin

As previously mentioned, groundwater in the portion of the Lobos Basin underlying the Presidio is managed by the Park Service. Groundwater is now used, along with water

from Lobos Creek, to supply the Presidio's potable water demand. The Water Department will conduct a study of the Lobos groundwater basin to determine how groundwater use at the Presidio affects groundwater levels and quality in Lobos Basin, to evaluate potential Water Department use of the basin, to assess the relationship of the creek to the basin, and to confirm estimates of Lobos Basin existing recharge and extraction rates. This study may be conducted either independently or jointly with the Park Service and may include the installation of monitoring wells, groundwater sampling, metering of Lobos Creek flows, and basin groundwater flow modeling. Information from this study will be used to support Activities 3B1 (Assess effects of groundwater development on Lobos Creek) and 5C2 (Conduct conjunctive use in the Lobos Basin).

Activity 5D2: Develop and Implement Studies of Other Shared and City Basins

The Water Department will develop and implement studies in each of the four remaining groundwater basins (South, Visitacion Valley, Islais Valley, and Marina Basins) as part of the overall effort to increase groundwater use within the City. Results of these studies will provide information to the Water Department regarding whether the groundwater in these basins can be developed for potable or nonpotable uses. These studies would be conducted to support Phase II implementation of the Recycled Water Master Plan, which may temporarily use groundwater in the southwest portions of the City.

Preliminary indications are that the potential groundwater use of these basins is lower than that of the Westside, Downtown, and Lobos Basins. However, use of these basins may assist the Water Department in meeting its long-term strategies and goals. Current plans do not call for studies of these other City basins within the next 5 years, but when performed they will provide the City with the information to evaluate their potential use. These studies may involve the following tasks:

- Install new groundwater wells
- Collect and analyze water quality and water level measurements from new and existing wells
- Conduct and analyze aquifer tests
- Conduct laboratory tests of soil samples collected during well installation (including tests for permeability, sieve analyses, and organic content)
- Analyze data collected during the studies (including developing geologic cross sections and groundwater flow modeling)

Data collected during the basin studies will be added to the Geographic Information System (GIS) database developed for this Master Plan. Additional studies may be conducted on one or more basins depending on the results of the first study. Before groundwater development is implemented, proposed activities will undergo a project-specific environmental review to identify possible environmental impacts. The Water Department's objective is to increase groundwater use without causing adverse environmental impacts.

Strategy 5E: Evaluate Other Potential Activities for Increasing Groundwater Use

Although Strategies 5A through 5C evaluate most of the potential activities for increasing groundwater use in the Westside and Downtown Basins, a number of smaller-scale potential activities remain. These consist of using groundwater in the City's decorative fountains and pools, and assessing whether groundwater could be used to treat pockets of water that could cause pipe erosion in the City's water distribution system. Under this strategy, the Water Department will evaluate these potential activities.

Activity 5E1: Evaluate, and Implement Where Feasible, Potential Groundwater Use in the City's Fountains and Decorative Pools

There are a number of fountains and decorative pools on both public and private properties around the City. The most notable of these are the lagoon at the Palace of Fine Arts; the Civic Center ponds; and the fountains at Justin Herman Plaza, the Chevron Building, the Hyatt Regency Hotel, the Marriott Hotel, and the Transamerica Building. Using groundwater in these fountains and pools would free up potable water for other uses and, in some cases, allow the pools and fountains to be used in drought years. The Water Department will evaluate the potential use of groundwater at these locations.

Activity 5E2: Evaluate, and Implement Where Feasible, the Potential for Groundwater to Help Control Corrosion in the City's Water Distribution System

The City's water distribution system currently contains localized areas of water that could cause pipe corrosion and, eventually, pipe leaks. The Water Department will evaluate whether blending groundwater with this system water would inhibit the corrosion process. The activity may include installing additional wells, analyzing groundwater samples, conducting baseline tests to evaluate the interaction between blended surface water and groundwater with the distribution system, and comparing groundwater quality with system water quality to identify any locations where blending of the two water sources would benefit system maintenance by lowering the potential for pipe corrosion.

Section Eight - Implementation and Financing

The purpose of this section is to summarize capital and operation and maintenance (O&M) costs, discuss the implementation schedule with aspect to financing issues, and evaluate likely sources of funding for the 30 short-term activities identified in this Master Plan. These short-term activities will support the Water Department's long-term strategies and goals for managing, developing, and using the City's groundwater resources.

Short-Term Activity Costs

The costs of short-term activities are summarized in Table 8-1 in 1995 dollars and, therefore, do not include the effects of inflation. Additionally, other activities may be identified during the course of implementing this Master Plan, which, if implemented, could result in increased costs for the program. Capital costs include design, construction, and one-time items such as implementation of a groundwater management group. The O&M costs are the projected annual costs to operate the activities included in each goal at full implementation, which occurs in year 5. The distribution of these costs in years 1 through 5 are discussed below under program financing.

The estimated costs per acre-foot of water for these activities are shown in Table 8-2. Only three of the short-term activities will directly produce estimated quantities of additional water. These three, all part of Goal 5, are capital-intensive and range in cost from approximately $206 per acre-foot to $526 per acre-foot, compared to a delivered water cost from the City's surface water supply of $450 per acre-foot. The other 27 short-term activities will either produce variable amounts of water (Activity 4A2–Design, install, and operate large-capacity standby wells, if appropriate) or are expected to indirectly yield additional water and/or associated benefits.

Table 8-1
Summary of Known Short-Term Activity Costs
(in 1995 dollars)

Type of Cost	Management Activities			Development & Use Activities		Total Cost
	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	
Capital Costs	$1,120,000	$97,000	$405,000	$2,534,000	$4,496,300	$8,652,300
Annual O&M Costs at Full Implementation (Year 5)	155,000	233,000	0	250,000	339,000	977,000

Table 8-2
Estimated Cost per Acre-Foot for Short-Term Activities
(in 1995 dollars)

Short-Term Activity	Annualized Capital Cost*	Annual O&M Cost	Total Annual Cost	Estimated Ac-Ft/Yr	Estimated Cost/Ac-Ft
5A1–Extract groundwater from Elk Glen Well; add to main distribution system	$ 72,000	$113,000	$185,000	900	$206
5A2–Extract groundwater from the Sunset District; add to main distribution system	230,000	191,000	421,000	800	526
5B1–Add groundwater to the AWSS from dewatering at the Powell Street BART station	12,900	35,000	47,900	150	320

*Capital costs shown as debt service. Activities funded by capital reserves have an annualized capital cost similar to revenue bond debt service, (i.e., with a 7 percent interest rate and 25-year repayment period) except that issuance and reserve costs are excluded.

Implementation Schedule

As shown in Figures 8-1 and 8-2, the Water Department will implement or construct the short-term activities currently identified over the next 5 years. This schedule assumes that all 30 of the proposed short-term activities will be financed using the combined revenue bond/pay-as-you-go funding approach discussed below. However, the Water Department may change this schedule as additional activities are identified and various short-term activities are modified.

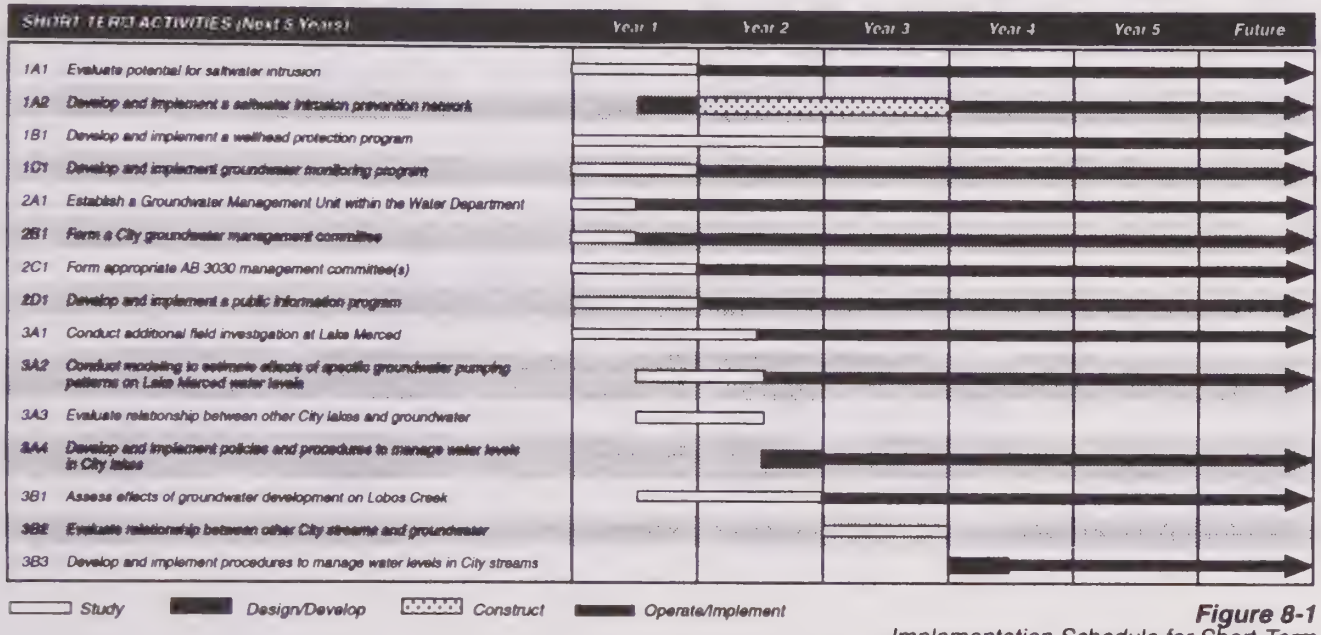


Figure 8-1
Implementation Schedule for Short-Term Groundwater Management Activities

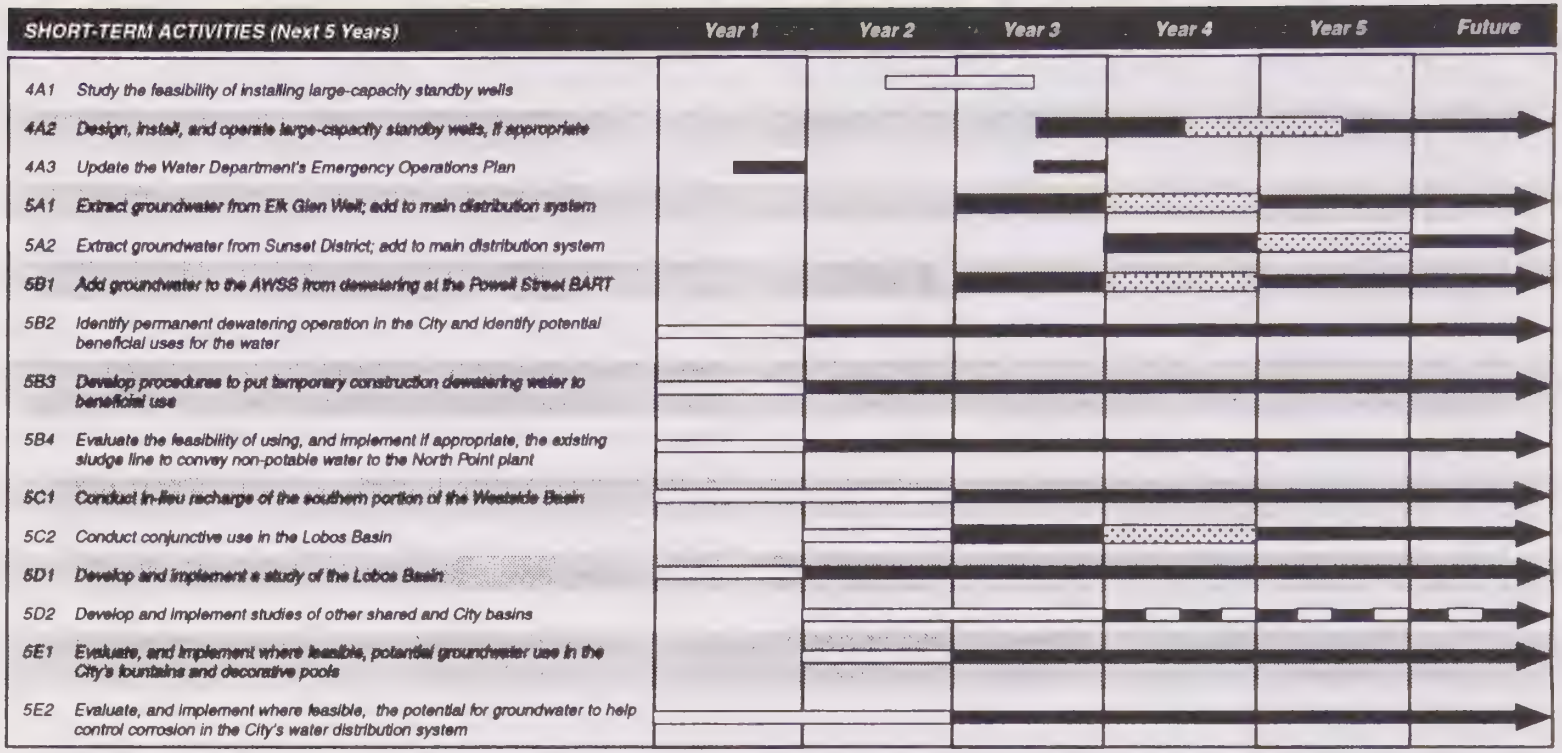


Figure 8-2
Implementation Schedule for Short-Term Groundwater Development and Use Activities

Program Financing

The Water Department will need to fund both the annual O&M costs and capital costs of the short-term activities for the management activities (Goals 1, 2, and 3) and the development and use activities (Goals 4 and 5). However, different funding mechanisms will be needed for each. The Water Department's basic water service charges will fund O&M costs, while revenue bonds and/or capital improvement reserves will be used to fund the capital costs.

In addition to the type of funding mechanism, the Water Department will consider two other factors related to program financing. The first is the effect of inflation on future costs. Table 8-1 summarizes costs in 1995 dollars, but inflation will increase the costs incurred after 1995. The second factor is the cost associated with long-term financing, such as revenue bonds. Although revenue bonds initially reduce the annual funding requirements by spreading the costs over the repayment period, they also carry a longer-term commitment, and the required issuance costs and bond reserves increase the principal amount to be funded. Both of

these factors will affect the Water Department's annual budgets and, therefore, are included in the following discussions.

Revenue also will be generated by this project. The Water Department will be able to sell the water produced by this project to wholesale and retail customers or to sell the surface water that will be replaced by groundwater. This revenue has not been estimated at this time or considered when developing the cost of implementing this Master Plan.

Funding of O&M Costs

The basic source of funding for annual O&M costs is the Water Department's water service charge. As shown in Table 8-1, at full implementation (year 5) annual O&M costs reach a total of $977,000 in 1995 dollars. When the effects of inflation are included, these costs increase to $1.14 million by year 5, as shown in Table 8-3.

When the annual O&M costs shown in Table 8-3 are added to the Water Department's annual revenue requirements, basic water service charges may go up. If rate increases are not viable, or if Water Department operating budgets are restricted, these O&M activities are likely to be evaluated in terms of their cost-effectiveness and may need to compete with other Water Department activities for funding. However, Activity 2C1 (Form appropriate AB 3030 management committee[s]) addresses the formation of a groundwater management committee under AB 3030 legislation, and one of the issues to be addressed is the equitable allocation of costs among member governmental jurisdictions and user groups. Reallocation of some O&M costs to other groups would reduce the impacts of these short-term activities on the Water Department's water rates.

Table 8-3
Projected Annual O&M Costs for Short-Term Activities

	Short-Term Implementation Period				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Management Activities					
Goal 1	$0	$161,200	$167,600	$174,400	$181,300
Goal 2	0	0	252,000	262,100	272,500
Goal 3	0	0	0	0	0
Development and Use Activities					
Goal 4	0	0	0	281,200	292,500
Goal 5	0	0	0	0	396,500
Total Annual O&M Costs	**$0**	**$161,200**	**$419,600**	**$717,700**	**$1,142,800**

Note: It is assumed that the City will fund all O&M costs of short-term activities from annual operating budgets. Costs include inflation, which is assumed to be 4 percent per year.

Funding of Capital Costs

The two basic approaches the Water Department is likely to use to finance the capital costs of these short-term activities are (1) pay-as-you-go, which would use current year revenues and existing capital improvement reserves for capital costs, and (2) a combined revenue bond/pay-as-you-go approach, with revenue bonds used to finance the larger projects and annual revenues/capital improvement reserves to finance the smaller projects. Projected annual costs under each of these approaches are discussed below.

Pay-As-You-Go Financing. If the Water Department uses a pay-as-you-go approach to fund all capital costs for the short-term activities included in Goals 1 through 5, the annual costs would range from a low of $516,700 in year 2 to a high of $4.2 million in year 5, as shown at the bottom of Table 8-4. This range of costs indicates the need to use revenue bonds, or other long-term debt, to help reduce the peaks in the annual cash flow requirements.

Combined Revenue Bond/Pay-As-You-Go Approach. All but two of the 30 short-term activities involve capital costs of less than $2.5 million. These two exceptions are Activity 4A2 (Design, install and operate large-capacity standby wells, if appropriate), and Activity 5A2 (Extract groundwater from the Sunset District; add to main distribution system), with estimated costs of $2.68 million (in 1995 dollars). These two activities would be financed with revenue bonds under this funding approach. Although the

Table 8-4
Projected Annual Funding Requirements for Short-Term Activities
Using a Pay-As-You-Go Funding Approach

	Short-Term Implementation Period				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Management Activities					
Goal 1	$1,040,000	$ 54,100	$ 30,300	$ 0	$ 0
Goal 2	42,000	36,400	21,600	0	0
Goal 3	295,000	104,000	10,800	0	0
Development and Use Activities					
Goal 4	14,000	20,800	2,704,000	0	0
Goal 5	293,000	140,200	260,600	1,378,400	3,044,000
Total Capital Costs	**1,684,000**	**355,500**	**3,027,300**	**1,378,400**	**3,044,000**
Total O&M Costs (from Table 8-3)	**0**	**161,200**	**419,600**	**717,700**	**1,142,000**
Total Annual Costs	**$1,684,000**	**$516,700**	**$3,446,900**	**$2,096,100**	**$4,186,000**

Note: This table assumes that the City funds the capital costs of short-term activities entirely from capital improvement of other existing revenue funds rather than revenue bonds. Costs include inflation, which is assumed to be 4 percent per year.

Water Department prefers to fund most of the short-term activities through existing capital improvement reserves, use of revenue bonds to finance additional activities may be necessary because of cash flow constraints.

In developing the implementation schedule and financing plan, the Water Department has considered both the amount funded through revenue bonds and the implementation and construction activities. This provides a schedule that is manageable for the Water Department staff, and one that does not exceed the Water Department's capital improvement reserve funds.

Using revenue bonds to fund individual projects over $2.5 million would result in a reasonable implementation schedule. Therefore, annual debt service payments are included instead of the entire capital cost for these two projects (4A2 and 5A2). The Water Department has included issuance costs and reserve requirements of 15 percent of the principal for these projects, and assumed an interest rate of 7 percent and a 20-year repayment period in estimating the annual debt service.

The resulting annual cash-flow requirements for the capital costs using this combined revenue bond/pay-as-you-go approach are shown at the bottom of Table 8-5. As a result of including the annual O&M costs from Table 8-3 in this combined funding approach, the annual cash flow requirements would range from a minimum of approximately $516,000 in year 2 to $2.35 million in year 4.

The portion of the annual cash flow shown in Table 8-5 that is debt service on the revenue bonds for projects 4A2 and 5A2 totals $1.04 million, compared to $5.6 million if

Table 8-5
Projected Funding Requirements for Short-Term Activities
Using a Combined Revenue Bond/Pay-As-You-Go Approach

	Short-Term Implementation Period				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Management Activities					
Goal 1	$1,040,000	$ 54,100	$ 30,300	$ 0	$ 0
Goal 2	42,000	36,400	21,600	0	0
Goal 3	295,000	104,000	10,800	0	0
Development and Use Activities					
Goal 4	14,000	20,800	255,200	255,200	255,200
Goal 5	293,000	140,200	260,600	1,378,400	425,100
Total Capital Costs	1,684,000	355,500	578,500	1,633,600	680,300
Total O&M Costs (from Table 8-3)	0	161,200	419,600	717,700	1,142,800
Total Annual Costs	**$1,684,000**	**$516,700**	**$998,100**	**$2,351,300**	**$1,823,100**

Note: It is assumed that the City will use revenue bonds to finance all individual projects over $2.5 million. Therefore, the annual debt service payments are included here for projects 4A2 and 5A2, which assume that issuance costs and reserve requirements will add 15 percent to the principal on these bonds. These costs include inflation, which is assumed to be 4 percent per year.

these projects were funded with capital improvement reserves. These bonds entail an issuance of $3.1 million in year 3 and $3.3 million in year 5, as shown in Table 8-6.

The annual cash flow requirements in both the pay-as-you-go approach (Table 8-4) and the combined revenue bond/pay-as-you-go approach (Table 8-5) assume that the short-term activities involving construction will begin operation immediately after construction. Development and use projects are expected to operate continuously from startup into the foreseeable future, except for those involving finite studies such as Activities 4A1 (Study the feasibility study of large-capacity standby wells, 4A3 (Update the Water Department's Emergency Operations Plan, and 5B2 (Identify permanent dewatering operations in the City and identify potential beneficial uses for the water). These and other finite studies are expected to be completed within a year.

Table 8-6
Revenue Bond Funded Portion of Short-Term Capital Costs
Using a Combined Revenue Bond/Pay-As-You-Go Approach

	Revenue Bond Funding	
	Bond Principal[a] and Issuance Date	**Annual Debt Service[b]**
Management Activities		
Goal 1	$0	$0
Goal 2	$0	$0
Goal 3	$0	$0
Development and Use Activities		
Goal 4	$3.1 million/Year 3	$255,200
Goal 5	$3.3 million/Year 5	$273,000
Total	**$6.4 million/Year 3-5**	**$528,200**

[a]Assumes an additional 15 percent for costs of legal, issuance, and bond reserve requirements.
[b]Assumes a 7 percent interest rate and a 20-year repayment period.

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